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A

TREATISE ON FRACTURES.

BY

J. F. MALGAIGNE,

CHIRURGIEN DE L'HÔPITAL SAINT-LOUIS, CHEVALIER DE LA LÉGION D'HONNEUR ET DU MÉRITE MILITAIRE DE POLOGNE, MEMBRE DE L'ACADÉMIE ROYALE DE MÉDECINE.

WITH ONE HUNDRED AND SIX ILLUSTRATIONS.

TRANSLATED FROM THE FRENCH,

With Notes and Additions,

BY

JOHN H. PACKARD, M.D.

PHILADELPHIA:
J. B. LIPPINCOTT & CO.
1859.

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TRANSLATOR'S PREFACE.

In presenting to the profession an American translation of M. Malgaigne's Treatise on Fractures, I beg to call attention to a few points connected with my own share in the work. The importance of the subject needs no comment to those who have had any practical experience in surgery; nor is it necessary to adduce any other proof of M. Malgaigne's position as a standard authority than the extent to which he is quoted by other surgical writers.

I have made it my great aim to render the text of the author as faithfully as possible, endeavoring at the same time to avoid offending the taste of the reader by the use of Gallic idioms. The notes which I have taken the liberty to insert are intended to set forth peculiarities in American views and practice, or accounts of cases in point; in one or two instances I have been able to look up quotations which were beyond my author's reach. An index has also been added, and a list, as full as circumstances would allow, of works hitherto published upon the same subject.

As a matter of course mention is frequently made, throughout the volume, of weights and measures. Where these occur, I have in some cases substituted English values, sometimes annexed English equivalents to the French expressions, and sometimes allowed the latter to stand by themselves. For the convenience of the reader, a table

will be added containing the French and English standards, and showing their relative proportions.

Most of M. Malgaigne's illustrations are comprised in a folio atlas of lithographic plates; these have been reduced one-half, and engraved on wood. For greater facility of reference, they have been collected at the end of the volume, instead of being interspersed throughout the text.

There are some French words which have a very different signification from that of their analogues in English; thus *simple* means with us, in regard to fractures, *excluded from the air;* while in French it corresponds to our word *single.* These differences have been explained in notes, wherever any confusion seemed likely to arise.

In conclusion, I must express my thanks to Dr. Norris, for his kind assistance in my search after several important references; to Dr. Henry D. Noyes of New York, and Dr. Christopher Johnston of Baltimore, for accounts of cases, and valuable information as to some practical points; and to Dr. F. H. Hamilton of Buffalo, for various original pamphlets bearing on the subject in hand.

1225 Spruce Street,
Philadelphia, 1858.

PREFACE.

I NOW offer to the public the first part of a work long since conceived of, with a view of filling a gap in our surgical literature. England and Germany have already produced several treatises upon fractures and luxations; and it is perhaps surprising that France should be behind-hand.

It is however necessary, in a matter so important, that we should be in possession of something more than is contained in our general treatises on pathology. We are beyond the time when Richerand declared that the treatment of luxations, for instance, was almost *in that ideal state called perfection.* Numerous recent works have shown how many errors and omissions exist in the history of this class of injuries, so that this fact does not need to be insisted upon here. In regard to fractures, the demonstration is not so clear; yet I am ready to assert that their study is not in a more advanced state than that of luxations, and that too often, in both, imaginary lesions are pointed out, and real ones unrecognised.

The character which I have mainly sought to give this work is that of reality. In a historical point of view, I have aimed at presenting a *resumé* of all the doctrines and ideas maintained from the earliest times to our own day, having recourse as much as possible to the original works. As to my teachings, I have asserted nothing unsupported by facts, drawn either from my own experience or from that of others. Where clinical observation was insufficient, I have

sought a substitute for it in experiments upon dead bodies, or upon the lower animals; but above all, I have tried to clear up a great many mooted points by throwing upon them the light of pathological anatomy; and this is the object of my atlas.

In order to enrich this atlas as much as possible, I have not hesitated to levy contributions in all quarters. Besides my own collection, I have drawn upon the three great museums of Paris; for the liberality with which these treasuries of science have been thrown open to me, I owe my thanks to the *Conseil des Hôpitaux*, and to M. Serres, director of the *Musée des Hôpitaux;* to the secretary of the *Faculté de Médecine* for the *Musée Dupuytren;* to M. Gama, for the museum at Val-de-Grâce. And since fortune is capricious, whenever I came upon a rare and important specimen in any cabinet, I hastened to secure it for the benefit of my atlas; in this way getting hold of perhaps more material than any other author has ever had.

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* [By some mistake the heading of this section has been made to read "Comminuted," in the body of the work. I trust the evident incorrectness of that title will prevent any one from being misled by it.]

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TABLE

SHOWING THE RELATIVE VALUES OF FRENCH AND ENGLISH STANDARD WEIGHTS AND MEASURES.

(From *Hoblyn's Medical Dictionary.*)

Millimètre	=	·03937	inches.	
Centimètre	=	·39371	"	
Decimètre	=	3·93710	"	
Mètre	=	39·37100	"	
Decamètre	=	393·71000	"	= 10 *yds.*, 2 *ft.*, 9·7 *in.*
Litre	=	2·1133	pints.	
Milligramme	=	·0154	grains.	
Centigramme	=	·1544	"	
Decigramme	=	1·5444	"	
Gramme	=	15·4440	"	
Decagramme	=	154·4402	"	= 2 dr., 34·3 gr. Troy, or 5·65 dr. Avoirdupois.
Hecatogramme	=	1544·4023	"	
Kilogramme	=	15444·0234	"	= 2 lb., 3 oz., 5 dr. Avoirdupois.

The millimètre may for general purposes be estimated with sufficient accuracy as = $\frac{1}{30}$ of an inch; the centimètre as = $\frac{1}{3}$ of an inch; the mètre as somewhat over a yard; the gramme as = about 15 grs. Troy; the kilogramme as something over 2 lbs. Avoirdupois. The *ligne* and the *pouce* correspond respectively to $\frac{1}{12}$ of an inch and one inch; and the *livre* to about 1 lb. Avoirdupois. Wherever greater exactitude has seemed desirable, as was stated in the preface, the English equivalents have been merely annexed to the French expressions, or the latter have been allowed to stand by themselves.

A TREATISE ON FRACTURES.

CHAPTER I.

OF FRACTURES IN GENERAL.

The word *fracture*, (*fractura*, from *frango*, I break,) or, in common language, breaking, conveys to the mind so clear an idea that a definition might, perhaps, tend only to obscure it. If, however, one must be adopted, I should say that fracture is the division, by violence, of bones or of cartilages.

The study of fractures in general is of such importance, that one may say that without it the history of each particular fracture would necessarily remain obscure and incomplete. In order to omit none of the questions it involves, we shall arrange it under seven heads, treating successively (1) of the etiology, (2) of the varieties, (3) of the symptoms, and (4) of the course and terminations of fractures—subjects belonging almost exclusively to pure science. Then passing to the application, which properly constitutes art, we shall take up (5) the diagnosis, (6) the prognosis, and (7) the treatment.

ARTICLE I.

ETIOLOGY.

We shall study, under this head, first, certain general predispositions, unconnected with any morbid state; second, the effects of disease in facilitating the occurrence of fractures; and, lastly, the immediate or determining causes.

§ I.—*General Predispositions.*

The general predisposing causes of fractures are connected with the influence of age, sex, and season; to which must be added those marked tendencies which exist in some parts of the skeleton.

(1.) *Influence of age.*—Fractures have been observed at all times of life, from the intra-uterine period to extreme old age, but by no means with the same degree of frequency; and Boyer has shown that in infancy the bones, being more flexible, escape fracture more easily, while in advanced life they are broken with far greater readiness. But these data are vague, and seem, moreover, to rest on theories rather than on facts. In order to establish the facts at once, I have brought forward the registers of the Hôtel-Dieu for the space of eleven years, from 1806 to 1808, and from 1830 to 1839; thus obtaining a sufficiently imposing total of 2377 fractures, classed according to age. I add, for greater clearness, a column showing the mean of the fractures furnished by every year of life in the corresponding periods:*

From 2 to 5 years,	13 fractures.	Annual mean,	4
" 5 " 15 "	101	"	"	"	10
" 15 " 25 "	289	"	"	"	29
" 25 " 60 "	1488	"	"	"	42
" 60 " 70 "	316	"	"	"	31
" 70 " 75 "	103	"	"	"	20
" 75 " 80 "	51	"	"	"	10
" 80 upwards	16	"	"	"	1 or 2

According to this table, it is seen that fractures occur most frefrequently in subjects of from twenty-five to sixty years of age, becoming more rare above and below these limits, as we depart from them respectively; so that as regards the rarity of fractures, the extremes of life approach one another: the first period (from two to five years) exceeding the last, (above eighty years,) and the fractures occurring in equal number in each year of these two other periods: viz., from five to fifteen years, and from seventy-five to eighty. This result, undoubtedly quite a curious one, still by no means indicates the real influence of difference in age; to obtain this we must compare, for each period of life, the number of fractures with the number of the population. This I have attempted, using the tables of the *Annuaire des Longitudes;* and the aspect of affairs is thus totally changed. Thus, for example, to the period of from five to fifteen years belongs nearly one-fifth of the entire population, while this same period furnishes hardly more than one twenty-third of the fractures. At fifteen years the predisposition suddenly increases; it remains almost the same up to twenty-five years, receiving then a new increase quite as sudden as the first; after which it takes but gradual steps up to sixty years; so that the two periods, for instance, from twenty-five to thirty years, and from fifty-five to sixty, giving a nearly equal number of fractures, the latter is under the influence

* *Etudes Statistiques sur les Fractures; Annales d' Hygiène Publique*, tome xxii. There have occurred in this work some errors in the figures, which I have taken care to correct here.

of a predisposition nearly double that of the former, since as many fractures occur in a population less by almost one-half.

But beyond sixty years, there appears quite an unexpected result. The number of fractures suddenly diminishes in the same ratio as that of the population; so that the predisposition, which till then has been constantly increasing, remains afterwards almost stationary; a given number of old men, as from seventy to eighty years, for example, affording a proportion of fractures not sensibly greater than an equal number between fifty-five and sixty. Above eighty years, the greater rarity of fractures becomes quite manifest, even deducting from the sum of the general population of that age the number of the indigent admitted into the two hospitals for the old.

So much for advanced age. Early infancy offers also, in this point of view, singularities hitherto unnoticed. From a *resumé* of four years' experience at the Hôpital des Enfants, it appears that of seventy-five fractures observed in patients aged from two to six years, there were,—

Between 2 and 3 years	20
Between 3 and 4 years	21
Between 4 and 5 years	6
Between 5 and 6 years	13
Between 6 and 7 years	15

And the number rests stationary during the following years, up to the tenth or twelfth. Likewise I found, having undertaken the duties of this hospital in the vacation of 1838, that of ten fractures four were in children between two and three years old, and six only in children between five and fourteen. Children below the age of two years not being admitted into the hospitals, I ignore statistics concerning them; but, at any rate, fractures appear to be quite common, relatively speaking, from two to four years of age—very rare from four to five; after which, as stated, the proportion increases year by year.

If, then, only the absolute number of fractures be considered, it is from four to five years of age that they are rarest, and from twenty-five to sixty that they are most common.

If we compare this number with that of the population, it is still the period from four to five years of age that affords fewest cases of fracture; but the one which presents most is from fifty-five to eighty.

If, now, we would ascertain why the facts should be as given above, we may suppose that infants from two to four years old, not as yet walking steadily, are liable to frequent falls, the effect of which is severe upon bones still of slight strength. After the fourth year, these two causes are less efficient, but are soon replaced by others, as the games, running, scuffling, etc. of children. At puberty are added to these the learning of trades, and from twenty-five to forty years, the fully developed muscular power of the man; after forty years,

the degeneration of the skeleton; and if this last and strongly-marked predisposition to fracture does not increase their number from fifty-five to eighty years, and even if, later in life, that number diminishes, it is because the debility of age exempts from the exciting causes, active labor, quarrels, fights, etc.

It may be seen that in this enumeration external causes are prominent, and that the fragility of the bones acts only in very early and very late life. Boyer thought that the bones of the old became more fragile by the increase of their earthy salts. According to well-known analyses, it is, on the contrary, proved that where the animal matters predominate the bones are more easily broken; and those which most resist fracture are the compact bones of adults. The fragility of the bones of some old men depends on a different cause: namely, an affection of the osseous tissue, enlarging the canals and thinning the walls of the diaphyses, thus increasing till finally the cells of the spongy tissue are made undistinguishable. These lesions I have described somewhat in detail in my *Anatomie Chirurgicale*, and they have led me to the following triple conclusion, since confirmed by my researches at Bicêtre:—

There are persons whose skeletons undergo hardly any modification in advanced life; and some even in whom the compact tissue becomes denser, and as it were eburnated; these are as little liable to fracture as adults.

In others, the absorption is limited to thinning of the spongy tissue; perhaps this is more commonly the case, and hence the large proportion of fractures of the ribs, cervix femoris, cervix humeri, etc.

Finally, in a still smaller number of cases, the absorption affects all parts of the skeleton, reducing the walls of the diaphyses to the thinness of pasteboard, or even less; softening the spongy tissue so that it is crushed by the fingers; and here fractures of every kind occur from the slightest causes. But the rarity of this affection forbids our considering it as a normal state, and I shall speak hereafter of its nature.

(2.) *Influence of sex.*—Men are more subject to fractures than women; the proportion was as five to two in my cases at the Hôtel-Dieu. But this result, true in general, is variously modified by differences in the period of life. Thus I found, for the age of two to five years, the number of girls affected with fracture to be nearly double that of the boys; the latter, on the contrary, were at least three times as numerous as the girls, between the ages of five and ten; and the proportion went on increasing in the succeeding periods, till in that between fifteen and twenty years there were 136 males to seventeen females, or about eight to one. Afterwards it diminishes, as up to the age of forty-five there were three, or perhaps four, fractures in men to one in a woman. This period passed, it still goes down, so that from seventy to seventy-five years the numbers are equal for

the two sexes; and beyond seventy-five years there are nearly double as many fractures in women as in men—infancy and old age again approaching one another.

Hence the influence of age differs in the two sexes; if it be true, or nearly so, that the man of seventy or eighty has the same predisposition to fracture as the man between fifty-five and sixty, this law is evidently incorrect as regards women, in whom the number of fractures sensibly increases from fifty-five to eighty in proportion to the population. To some degree, these differences can be explained; in early infancy, by the slower development of female children, which renders their skeletons less solid; a little later, by the differences in education between boys and girls; still later, by their differences of occupation; and finally, in the period of old age, the ravages of time are more rapid and marked in the female, and exert more influence in the degeneration of her osseous tissue.

(3.) *Influence of the seasons.*—A. Paré has stated that the bones were more fragile during the winter, and in time of frost—a theory which I do not think tenable; and modern surgeons have accepted his assertion, without ever verifying it. It much needs proof, nevertheless, that the difference between winter and summer is as great as one would be led to suppose; and by the most favorable estimate, taking the figures of my eleven years *en masse*, and contrasting in each the four months from December 1st to March 31st with the other two similar periods, an excess of one-eighth in the sum of the fractures in the winter season over that in the summer is the utmost that I have found. Dividing the year into four periods, of three months each, the proportion is still less; as, for example, from 1834 to 1837, the spring months presented more fractures than any others. Lastly, if we contrast the single months one with another, we frequently find a summer month equal to, if not exceeding, a winter month; thus, in our eleven years, February showed constantly fewer fractures than June or October.

To weigh the circumstances carefully, falls are doubtless more frequent in the winter, the ground being slippery; but these falls are generally slight, while in mild weather, when masons, carpenters, etc. resume their labors, the falls which occur are apt to be from heights, and hence far more dangerous. And this is not mere hypothesis; we shall see, in fact, that among adults so employed as many fractures are sustained in summer as in winter, while to weak old men the latter is the more perilous season. For greater simplicity, I have divided the year into only two periods; the result is as follows:—

Ages.	Winter.	Summer.	Proportions.
From 2 to 15 years,	47 fractures.	66	71 to 100
" 15 to 25 "	126 "	163	77 to 100
" 25 to 45 "	432 "	429	equal
" 45 to 55 "	225 "	188	120 to 100
" 55 to 80 "	422 "	272	155 to 100
Above 80 "	8 "	8	equal

As regards adult age and extreme old age, this table needs no comment; evidently between twenty-five and forty-five years all seasons are equal; and on the other hand, above forty-five years, winter makes its influence felt more and more as age advances. Only after the eightieth year the occurrence of fractures according to the seasons seems to obey exceptional laws.

But what has doubtless struck the reader, is the singular difference between earlier and later times in the opinions entertained on this point. In infants and children, not only are fractures not more frequent in the winter, but they are notably fewer than in the summer. I have met with the same difference in the Hôpital des Enfants; where, of 137 fractures observed from 1834 to 1837, eighty-four occurred in the warmer six months of the year. How shall we explain a fact so new, and so contrary to received opinions? Is it not because in winter children are carefully kept in the house, while in summer, in running about and playing, they are more exposed to the causes of fracture?

However this may be, the winter season is not really unfavorable except to the old; and as the female skeleton undergoes a more marked deterioration in advanced age than the male, we should presume *a priori* that a notable proportion of fractures occurring in cold weather would be sustained by women. This conjecture is confirmed by the following statistics:—

In summer - - -	819 men - - -	297 women
In winter - -	861 men - -	400 women

Hence winter, adding but one-sixteenth to the number of fractures in the male sex, adds one-third to those in the female; and I am satisfied, besides, that this increase affects mainly old women; so that the number of fractures in women over fifty years of age is in winter nearly double what it is in summer.

(4.) *Predispositions in certain parts of the skeleton.*—It is not very long since the attempt was first seriously made to draw up the statistics of fractures, in order to appreciate better than from hypotheses the degree of predisposition of each bone. Desault conceived the idea, but never carried it out. I have mentioned, in the memoir already quoted, the partial attempts made at the Hôtel-Dieu, in Paris; the more extended tables of Martin, for twenty years, from the Hindoo Hospital, at Calcutta; of Lonsdale, for six years, from the Middlesex Hospital, London; to which must be added an analogous work by Wallace, for the Pennsylvania Hospital, in America, from its foundation in 1751 down to 1838.* Unfortunately,

* See "*The Quarterly Journal of the Calcutta Med. and Phys. Society*" for January, 1838; Lonsdale, op. cit., p. 18; "*The British and Foreign Medical Review*" for July, 1838.

we are not quite certain of the real value of these documents; I had myself conceived the idea of bringing to bear on this subject the registers of the Hôtel-Dieu since 1790, when I was foiled by the inaccuracy of the diagnoses there recorded. I have confined myself, therefore, to the examination of eleven years, during which, as an exception, the registers gave the diagnosis on admission, subject to that of the attending surgeons on duty; yet even here in some cases the designation of the bone fractured has been omitted, and in others the diagnosis is wanting in precision. Apart from these defects, I believe the following table may be regarded as more exact than any of the others:—

Fractures of the skull	53
" " " upper maxillary and malar bones	3
" " " nasal bones	12
" " " lower maxillary bone	27
" " " vertebræ	11
" " " pelvis	7
" " " sacrum	1
" " " coccyx	1
" " " ribs	262
" " a costal cartilage	1
" " the sternum	1
Total of fractures in the trunk	379
Fractures of the clavicle	225
" " " scapula	4
" " " shoulder	8
" " " cervix humeri	26
" " " humerus	284
" " " elbow	2
" " " olecranon	9
" " " forearm	107
" " " ulna	29
" " " radius	160
" " " carpus	13
" " " metacarpus	16
" " " phalanges of the fingers	42
Total of fractures in the superior extremities	925
Fractures of the cervix femoris	104
" " " femur	199
" " " knee	5
" " " patella	45
" " " leg	515
" " " tibia	29
" " " fibula	108
" " " foot	9
" " " toes	10
Total of fractures in the inferior extremities	1024

Thus, then, are classified 2328 subjects affected with fractures of a single bone, or of several parallel bones, as the ribs, bones of the leg or forearm, etc. To these add thirty other cases of fractures, more numerous or otherwise combined, involving both legs, or the leg and the thigh, etc., a species of complication to which I shall recur in connection with multiple fractures; and there will remain of our whole number nineteen fractures, the seat of which is not defined.

If, comparing this table with the more authentic of the other documents, we seek to deduce some results, we may say at once, in general, that fractures are more common on the right than on the left side of the body; undoubtedly because, the right side being more robust and more practised, we instinctively put it forward, whether for attack or for defence. The proportion is variable, and the excess in favor of the right side is not more than one-quarter.

If we consider separately the bones of the trunk and those of the members, we find fractures of the former notably rarer than those affecting the upper extremities, and these again less common than those of the lower extremities.

Boyer thought that the more superficial bones were more liable to fracture than the rest; this is not true except for the tibia, which, indeed, is more frequently broken than any other bone. But close upon the tibia comes the femur, one of the least superficial bones; and among the rarest fractures are those of the acromion, olecranon, calcaneum, and sternum; all of which are just beneath the skin. Hence it is the long bones which are oftenest broken; and this law holds good in the trunk also, in the ribs. Again, the tibia and the radius, which, in falls on the feet or hands, sustain mainly the weight of the body, exceed almost all the other bones in the frequency of their fractures.

Quite recently it has been stated that fractures of the diaphyses occur more usually in adult age, and intra-articular fractures chiefly in the old.* But this assertion is much too general, and can only be sustained in reference to fractures of the cervix femoris. There are, indeed, fractures which are more common at some periods of life than at others; those of the cervix humeri and cervix femoris, intra or extra-capsular, are, as it were, the painful appanage of advanced years, while fractures of the shaft of the femur, common to all ages, occur with far more frequency in youth than at any other time of life. Others are quite unequally divided between the sexes; women sustaining a large proportion of the fractures of the cervix femoris, of the cervix humeri, of the carpal extremity of the radius; while it is but rarely that we are called upon to treat, in them, fractures of the nasal or maxillary bones, of the metacarpus, or of the phalanges. The seasons have also their effect in favoring the occur-

* *Dict. des Dictionnaires de Médecine*, art. *Fractures*.

rence of certain fractures; but the study of these curious etiological conditions may be better carried out with that of each particular fracture.

§ II.—*Of some Affections predisposing to Fracture.*

All these affections may be arranged under two heads, according as they render the osseous tissue more fragile, or increase inordinately the power of the muscles acting on the bones. Cases are recorded of fracture due to violent convulsions; but I shall return to this point in speaking of fractures by muscular action, and treat here only of affections impairing the cohesion of the osseous tissue.

These are, first, such as attack the entire economy, and for this reason are called diatheses or cachexies. Such are scurvy, gout, cancer, syphilis, scrofula, and rachitis.

(1.) *Scurvy.*—Every year, in the spring, scurvy appears at Bicêtre; I have seen it in several cases of fracture, but never saw a fracture attributable to it. Still, when its signs are well marked, its effect on the bones is manifest. In the epidemic which in 1798 prevailed at the Hôpital Saint Louis, Poupard and Saviard found in several cases the bones softened, increased in volume, easily crushed, and the epiphyses readily separated. In a very young child, examined by Saviard, the softening was confined to the two femoral bones. M. A. Bérard has cited also the case of a female patient at la Salpêtrière, in whom scurvy had acted upon a portion only of the skeleton; the bones of one lower extremity being found infiltrated with blood, and easily broken by the slightest touch.*

(2.) *Gout.*—Various authors have mentioned gout as predisposing to fracture; yet to support this assertion I have been able to find but two instances, and those by no means conclusive. There is, first, the account given by Sarrazin, of a man, aged 60, affected for two years with an *arthritis pituiteuse* in the right shoulder and elbow-joints, who broke his right humerus in putting on his glove; the fracture was double, one point being four or five fingers'-breadths below the shoulder, and the other lower down, near the elbow. No callus was formed, and the patient dying two months afterwards, the humerus was found completely carious; in other words, softened, and easily crushed with the finger. He had denied ever having had syphilis.†

The second case was published by Kruger-Hausen. A woman, aged 76, had suffered for several years from gouty and shooting pains in the limbs, which kept her quite bent up. One day, wishing to sit down, and feeling for her chair with the right hand, she broke the

* *Mém. de l'Acad. des Sciences,* 1699, p. 169; Saviard, *Nouv. Recueil de Observations,* obs. 81; A. Bérard, art. *Fractures,* du Dictionnaire en 30 volumes.

† Fab. Hildani, *centur.* li, obs. 66.

cervix humeri of that side. At the end of six weeks, consolidation being nearly completed, she stepped on her dress, put out her left hand to disengage it, and broke the left humerus at the corresponding point. From this time she kept her bed; and again, being turned in order to receive an enema, a sudden crack announced a fracture of the cervix femoris.*

Even if these two persons were affected with gout, properly so called, their ages would still forbid our considering that as the sole and real cause of the fragility of the bones. In the Musée Dupuytren may be seen several skeletons of gouty subjects, which have suffered anchylosis of nearly all the joints, but not one of which bears traces of fracture. M. Mercier, indeed, claims to have observed in the bones of old gouty persons a large amount of medullary fat, seeming to indicate that this disease favors the occurrence of senile atrophy in the skeleton; but I apprehend this statement to be too general, and have not myself seen that the bones of the gouty are more frail than those of other subjects.

(3.) *Cancer.*—The influence of cancer on the osseous system is far greater; but it must be owned that it appears in but a very small number of cases, and under conditions as yet but little known. I have frequently seen patients die at Bicêtre with all the marks of the cancerous cachexia, and who besides have come to this hospital only after having undergone several operations and as many relapses; but I have seen in none of them this fragility of the bones, which has been noticed sometimes in patients apparently in a much less advanced stage of the disease.

The first example of this kind was published in 1723, by J. L. Petit. An old woman had long had a cancer of the breast, which troubled her only from time to time; there appeared at the middle of the left femur a swelling, involving the whole circumference of the bone, with constant pains. In turning herself in bed, she broke the thigh, and the pains ceased at once. Similar tumors formed in the humerus and clavicle; these bones were likewise broken, and finally the patient died.†

[James Ring, an Irish shoemaker, aged 35, received a blow with a hammer on the left thigh, in the summer of 1855; three weeks after, he twisted his leg in assisting to lift a heavy barrel, and thought it broken; he lay a month in bed without treatment, then walked to one of the college dispensaries. He received here a blister and a stimulating liniment, and used these; lay in bed three weeks. Nov. 3. He experienced great pain in the evening, and next morning found his thigh fractured and much bent, the angle salient

* *Med. Chirurg. Beobachtungen,* von Dr. Kruger-Hausen; quoted in the *Journal de Graefe et Walther,* tome iii, p. 647.

† *Malad. des Os,* 1823, tome ii, p. 363.

anteriorly. He was now admitted into the Pennsylvania Hospital, and treated by the ordinary means until Feb. 26, 1856; then, at his urgent request, no union having taken place, the limb was removed. A mass of medullary cancer involved the bone at the seat of the fracture. The stump healed well for some time, until a fungous mass grew from the end of the bone. This fungus was very vascular, and repeated hemorrhages from it greatly reduced his strength. Disease of the lungs was plainly indicated on physical examination. June 3, 1856, he died, and in the stump and lungs were found immense deposits of cancerous matter. Other organs healthy.]

It is not even essential that the fracture should be preceded by the local tumor of the bone. Mareschal has given the case of a woman of forty-five from whom he removed the mammary gland, and who, after cicatrization was completed, felt severe pains all through the body; one day, in turning herself in bed, she broke the femur close to its neck. Morand saw a precisely similar instance. In each of these cases, death occurring soon after, the femur was found softened and carious; in the first, it is added that the periosteum was detached, and that the color of the skin was unchanged.* Louis's case is better known. It occurred in a nun, aged 60, whose arm was broken by a coachman in helping her into a carriage. No callus was formed; seven months after, while sitting in an elbow-chair, and carelessly dropping her hand upon her thigh, her femur was fractured by this slight shock; and Louis, struck by this fragility, learned at last that the patient had an ulcerated cancer of the breast.

In these three cases the fractures were not consolidated; it is important to know if non-union is the law for fractures induced by cancer. Pouteau has reported a case of exception to the rule. He had removed an ulcerated cancer of the breast from a woman, aged 45. Cicatrization took place wonderfully well; but at the end of a year pains came on in the hips and thighs, so as to compel the patient to keep her bed; a year later, as her servant was moving the thigh, the femur gave way with severe pain, soon followed by a considerable swelling. Pouteau placed her on the use of ice-water and pills of butter of antimony; but a copious salivation obliged him to abandon the use of these pills at the end of a month. The consolidation was not hindered by this, and the patient lived for two years, at the end of which time she died of dropsy.†

Was it here really cancer which affected the bones? Pouteau says himself that his patient had had, several years before the formation of the cancer, *une humeur rhumatismale*, which even attacked the two wrists the third day after the operation on the breast. I certainly should not say that the presence of a cancer in the economy

* *Mém. de l'Acad. de Chirurgie*, tome iii, pp. 49, 50.
† Pouteau, *Œuvres Posthumes*, tome i, p. 75 et seq.

would be an obstacle to the uniting of a fracture. Dupuytren several times saw fractures consolidated in due time in women who had cancer of the breast or of the uterus; but the question is whether callus would form upon the bones made fragile by the influence of a cancer elsewhere.

The earliest autopsies properly made in this kind of fracture were those of Dupuytren. In a woman, aged 54, he saw tumors of a black, soft, spongy substance, of the size of an almond, seated here and there on the femur, and which, when detached, left openings leading to the medullary canal. The latter was very large, and its walls thin and crumbling. Similar degeneration had occurred in the pubis and in the ribs. In another case, a cancerous tumor of the size of two fists occupied the seat of fracture, and adhered to both fragments; the other bones were friable, but nowise changed either in form or color.*

Here we see the fragility to be due to two causes—the thinning of the bones, and the development of cancerous tumors at their surface. At other times the degeneration occupies the interior of the bones. Thus M. Blandin found the neck of the femur, fractured much as in Dupuytren's case, transformed into an osseous shell, inclosing a scirrhous mass, compact, creaking under the knife like bacon-rind, yellowish on the outside, and reddish toward the centre. The compact substance of the femur and of the other long bones crumbled into small fragments at the slightest touch, and the medullary canal contained, in place of the marrow, a matter similar to that found in the neck of the bone. The cranial bones were likewise softened.†

I have seen similar disease among the bones presented to the Academy, by Sanson, in 1834. A woman, aged 40, had a cancer of the breast, which she dated from seventeen or eighteen months previous, and under which she had evidently failed; there were now felt some tumors in the abdomen. In moving in bed she broke her thigh; the interne, in endeavoring to treat this fracture, broke the corresponding bone on the other side. Death soon took place, and at the autopsy there were found scirrhous masses, some of them softened, in the abdominal walls, lungs, liver, etc. The osseous system was stuffed with them; they occupied the substance of the cranial bones, and one, the size of a nut, had traversed the entire thickness of the os frontis. The spinal column, sawed open longitudinally, presented an extraordinary quantity of these masses in the bodies of nearly all the vertebræ; they existed also in the extremities and medullary canal of each femur. They seemed to have grown from within outward. Where they were most developed the osseous pa-

* Dupuytren, *Leçons Orales*, tome i, p. 49 et seq.
† *Gazette des Hôpitaux*, 1832, tome vi, p. 522.

rietes were proportionally thinned; and at these points, thus weakened, the fractures had taken place. M. Cruveilhier has had different parts of this skeleton represented in connection with other analogous observations.*

To sum up, the fractures which occur almost spontaneously in cancerous subjects would seem to be, in the majority of cases, due to cancerous degeneration of the bones themselves, and are then absolutely incurable. In some exceptional cases, the bones alone seem affected by what resembles senile atrophy; of this Rumpelt has cited an instance:—A woman, aged 60, had had induration of the mammary glands for four years. Flexing the right thigh in her sleep, the femur gave way in two places. Death ensued soon after, and then it was found that all the true ribs were fractured; but no trace of cancerous deposit was detected in the skeleton.† Then the callus may be regularly formed, as probably occurred in Pouteau's case. I would add that this atrophy may be in some sort partial or local. Thus, in a woman whose breast I removed for cancer, and who died from its return, I found the thickness of the subjacent ribs diminished to about two millimètres (one-fifteenth of an inch.) They were also softened, gorged with blood, and easily bent or broken, but otherwise without any trace of degeneration. The ribs on the other side, and the rest of the skeleton, were in a perfectly normal state.

(4.) *Syphilis.*—Like cancer, syphilis seems sometimes to exert an influence on the bones, the more mysterious from its rarity, and from the fact of a majority of patients escaping it. Attention was first called to this subject by Marcus Donatus. He gives the history of a Portuguese, affected for several years with constitutional syphilis and tophaceous tumors of different bones, which seemed at last to yield to mercurial frictions. One day, throwing half an orange at a comrade, he fractured the right humerus. Consolidation was hardly effected, when, in extending his left arm from the bed to reach the chamber, the humerus on that side gave way also; this united with equal readiness.‡ Since then, facts of this kind have multiplied; cases are even cited of non-union attributed to syphilis, in which consolidation followed the exhibition of mercury. I shall recur to this when speaking of treatment; merely adding, for the present, that the anatomical state of bones thus weakened by syphilis is as yet unknown, and that in old men it acts mainly by favoring atrophy of the skeleton.

(5.) *Scrofula.*—Fragility of the bones from this cause is still more rare, and I have hardly been able to collect any instances of it. Dupuytren has recorded the case of a little girl of eight months, of scrofulous constitution, who suddenly, and without previous complaint,

* *Anatomie Pathologique du Corps Humain*, livraison 20, pl. i.
† *Gazette Médicale*, 1835, p. 641.
‡ M. Donati, *De historiâ medicâ mirabili, Lib. sex;* Lib. v, cap. i.

waked in the night with loud cries. It was considered an attack of flatulent colic; but after three days her mother detected a swelling at the middle of the thigh. The surgeons consulted gave various opinions; some considering it a mere curvature of the bone, others a swelling caused by cold. Finally the fracture was recognized, and, under Dupuytren's treatment, united at the end of five months.*

Goodwin's case is quite a remarkable one. Mary Bradcock, aged 32, of relaxed fibre, pale complexion, and brown hair, having always enjoyed pretty good health, temperate in her mode of life, and never having used mercury, felt, in the winter of 1783, pains in her limbs. These she attributed to rheumatism; but one day, having struck her foot against a brick, she was not a little surprised at finding a fracture close to the ankle. Before her recovery from this accident was complete, she became pregnant for the eighth time; and one day, as her husband was helping her out of bed, she broke her left thigh without any violence whatever. Her accouchement was favorable; but soon afterwards she fractured her left arm by merely putting it over the neck of a person who was helping to lift her. Afterwards, while in bed, she broke her right thigh, first near the hip, and some time afterwards lower down, near the knee; then the clavicle; then the right arm; and again the right femur, hardly cured of its two former fractures—in all, eight fractures in the space of eighteen months, without any evident cause. But before the occurrence of each fracture, she experienced constantly, during several weeks, a considerable pain at a certain part of the bone, which went on increasing till the fracture took place, and then disappeared for a few days. At the time the observation was made, she complained of a pain a little above the elbow, threatening her with a ninth fracture. For each fracture there was employed merely a light bandage. The callus formed in five or six weeks. Dr. Hamilton, who carefully examined her, found nothing abnormal in the perspiration or urine. Her complexion indicated a strumous tendency; and, indeed, several of her family, even of her own children, were affected with scrofula; but she herself had never suffered from it.†

Would these facts sufficiently test the influence of scrofula in producing fractures? I would hardly affirm it. As to the first case, a single fracture proves but little; as to the second, fractures so numerous seem to me to prove too much; a fragility so remarkable could not but be attributed, in my opinion, to a rachitic constitution.

(6.) *Rachitis.*—Rachitis is perhaps the affection which most of all predisposes to fracture; but I do not limit the use of this name to the *rickets* of children; we must trace it in adult age and senility,

* *Leçons Orales de Dupuytren,* tome i, p. 43.
† *Journal de Médecine,* tome lxxvi, p. 81.

to get a complete idea of it, and must besides clearly distinguish its periods, to comprehend well its effects.

Rachitis begins by a peculiar state of the bones, which I can compare to nothing better than to the red softening induced by inflammation; the bone is then lighter and more fragile, and fractures occur very readily. At a more advanced period, the salts of lime diminish more and more, and with them also the solidity of the bone, which is at some points nearly carnified, bending and curving instead of breaking; but sufficient fragility remains in portions of the skeleton to give rise to fractures as well as curvatures. Finally, the progress of the complaint being checked, the osseous tissue ordinarily regains, little by little, its former solidity, or even passes into the state of eburnation, making fractures as difficult, or more so, than in the normal condition; or perhaps restoration does not occur, the bones remaining weak, thinned, with enlargement of the cells of the spongy tissue and of the medullary canals in the diaphyses; in which case, not only are fractures more common, but sometimes the atrophy of the bone goes so far that consolidation takes place slowly and with difficulty, or not at all.

Instances of multiplied fractures in rachitic children are abundant; but it must be remarked that they rarely occur before curvature—doubtless because the children, being infirm, are kept in bed; and that they mostly take place during convalescence—that is to say, when the twisted bones have acquired firmness enough to allow of walking and exercise. A little boy, six years old, whose father was healthy, but whose mother was rachitic, and whose legs and thighs had been distorted in early infancy by rachitis, fell, in playing. He sustained a fracture of the left humerus, unaccompanied by pain, and very regularly consolidated in one month. A year after, in playing, he broke the left femur at the middle, likewise without pain; union ensued in forty days. Three months went by, and he was entirely cured, when, in leaning from his bed to pick up some object from the ground, he again broke the same thigh, but this time at the lower third. Forty days again sufficed for union; but the child's enfeebled health obliged him to go on crutches. Finally, at the age of ten, one of his crutches slipping, he fell and broke the right femur at the middle. It was for this fracture that he entered the Hôpital des Enfants, where I was on duty in the summer of 1838, and where I recognized the traces of the preceding ones. This appeared to be transverse; it caused no more pain than the others, and was perfectly united by the forty-second day. He had thus had in four years as many fractures, arguing badly for his future prospects.

Jacquemille has traced much further a patient of the same class, born of healthy parents, but affected from his first year with general rachitis, which had flattened his ribs, distorted his spine, and curved all the long bones except the humerus. He could not walk till five

years old, and remained always excessively small and feeble. Toward the age of twelve, in mounting a wood-pile, he fell and broke the right arm at the middle. The fracture was simple, and united perfectly. At fifteen, trying to get up behind a carriage, he lost his footing, and fractured both thighs; which uniting with deformity, he was permanently crippled on the right side. At seventeen, he broke the left arm. At twenty-eight, he broke the left thigh, at a different point from before. Finally, at thirty-two, he again broke the right thigh, likewise at a new point. The case was not observed further.*

In the Musée Dupuytren (No. 516) may be seen the skeleton of a child six or seven years old, affected with general rachitis. It presents fractures of two ribs, of both clavicles, of both ulnæ, of both bones of both legs, and lastly, of the right thigh in two places—in all, twelve fractures. Lonsdale saw a young girl almost all whose bones were attacked with rachitis, and who had successively twenty-two fractures, occurring from the slightest causes. In all consolidation took place in the usual time. In the London Medical Gazette is given the history of another young girl, who, between the third and fourteenth years of her life, sustained thirty-one successive fractures, all in the long bones of the extremities; and, what is remarkable, the first occurred during the first stage of rachitis; viz., before the appearance of any curvature.† Lastly, it is said that Esquirol had in his anatomical collection the skeleton of a rachitic female, nearly all whose long bones had been broken in two, three or four points of their extent. There were thus counted more than two hundred fractures, all more or less united.‡

In adults, rachitis rarely reaches the stage of carnification and curvature of the bones; still, this is known to have occurred in several instances. The most celebrated of these is that of the woman Supiot, in whom nearly all the bones had undergone the strangest distortions; even at the autopsy, they could at many points be bent without breaking, although at others they displayed extreme fragility.§

But it is more common to see rachitis arrested at the period of red softening, which perhaps it never passes in individuals over forty years old. Then we see the spongy tissue broken down, the spine curved, the cervix femoris depressed, flattened, kneaded, as it were, by the pressure of the cotyloid cavity, or by its own pressure on the acetabulum, etc.; and hence the various deformities of the articulations in some old persons; but the diaphyses, remaining inflexible, are broken by the least shock. I would not imply by this that the spongy bones better resist fracture; and it is well known that the cervix

* *Journal de Médecine*, tome lxxvii, p. 267, and lxxxiv, p. 216.
† *London Medical Gazette*, 1833, vol. xii, p. 366.
‡ Art. *Fractures, Dict.* en 30 volumes.
§ Morand, *Opuscules de Chirurgie*, part ii, p. 224.

femoris, which is in old people first affected with softening, is also in them the portion of the skeleton most frequently broken.

I think it very likely that the fragility of the bones said to be caused by the influence of syphilis, scrofula, or gout, belongs to the rachitis of adult age and senility; it shows itself besides in cases where none of these causes can be imputed. Saviard has given the history of an unmarried woman, thirty years old, admitted into the Hôtel-Dieu for excessive pains in the whole body, without fever, and with no symptom of syphilis or of any other disease. When she had been in bed three months, unable to walk, her bones broke so easily that she could hardly be touched without causing a new fracture. At the autopsy, fractures were found in the thighs, legs, and arms, the clavicles, the ribs, the vertebræ, etc.; all the bones were filled with a reddish marrow, and crumbled under the fingers.*

It would be superfluous to cite instances of the fragility of the bones in old people, and I will merely mention the case of Seraphin, the director of the *Ombres Chinoises*, which I have given in my *Anatomie Chirurgicale*, and that of a woman at la Salpêtrière, in whom M. Cruveilhier found at the autopsy fractures of the right leg, left femur, and right radius, and two or three fractures in nearly all the ribs.† The state of the bones was like that observed by Saviard; like that in infantile rachitis, at the stage called by M. J. Guérin *rachitic consumption* of the skeleton; like, finally, though in a less advanced stage, that found in old people affected with what is commonly called senile atrophy.

As local predisposing causes, writers have mentioned caries, necrosis, tubercle, ulceration from the pressure of an aneurism or of a malignant tumor, the development of hydatids in the bones, osteosarcoma, etc. Doubtless all these affections tend to lessen the solidity of the bones, and hence favor fracture; and it would be easy to adduce instances to prove this; but the fractures occurring under such circumstances would be, as it were, merely incidental to the principal disease; this requiring all the attention of the surgeon, while they would be better placed under the head of complications.

But a much more frequent cause, and one by far too much neglected, is local inflammation of the osseous tissue. I designate thus, by conjecture, an affection manifested generally by dull pains, referred by the patient to a previous contusion, or to an attack of rheumatism; these are rarely severe enough to excite general reaction, and attract little attention, until at last, by slight violence, a fracture is caused at their seat. I have seen a young man of twenty, strong and of good constitution, fracture the femur by a fall on perfectly even

* Saviard, *Nouv. Recueil d'Obs. Chir.*, obs. 62.

† Cruveilhier, *Essai sur l'Anat. Pathol.*, tome i, p. 193.

ground. For several weeks he had suffered, at the exact point of the fracture, pains which he attributed to rheumatism.

The majority of fractures of long bones by muscular action are brought on, so to speak, just in this way. Nicod has cited two remarkable instances of this. A journeyman joiner had felt for a month severe rheumatic pains in the left arm; a fracture occurred from his resting his left hand firmly on the crank of a windlass, which he was turning with his right. A laborer broke his right arm in throwing a stone; he stated that he had always enjoyed good health till a month previous, when pains had come on in this arm, so severe as almost to prevent his working; but he had had no fever, nor lost his appetite for a single day.* I shall cite similar facts in connection with fractures of the patella; and whenever we are called upon to apply great force to the bones, as in reducing old dislocations, I regard it as an important precaution to ascertain first that the patient has not experienced steady pains in the member luxated.

Atrophy of the bones, with diminution of their thickness, often attends unreduced dislocations; but it oftener results from the immobility of paralysis. Thus the want of muscular action predisposes to fracture by enfeebling the structure of the bones; on the other hand, an excess of it leads to fracture by subjecting the skeleton to violence beyond its natural powers of resistance. Epileptics, during their attacks, and persons subject to violent and repeated convulsions, are naturally exposed to fractures from muscular action; but here the predisposition becomes blended with the immediate causes, to which reference will be made directly.

§ III.—*Of the Determining Causes of Fractures.*

The immediate causes of fractures are of two kinds; external violence, and muscular action. A case has been reported of fracture of a rib, attributed to the beating of the heart; but the reality of this as the cause was rather presumed than ascertained; it will be again referred to at the proper time and place.

Fractures by external violence are much the most common. When the bone yields at the point where the force is applied, we say the fracture is *direct*, or by *direct violence;* when at some other point, it is said to be by *contre-coup*, *counter-stroke*, or *indirect violence.* But it is not always easy, in practice, to determine whether a fracture is caused by direct or indirect force; and although blows generally break the bone at the point struck, and falls oftener act by counter-stroke, yet there are so many exceptional cases, that the external causes of fracture cannot be classed otherwise than by their presumed order of frequency. Falls, then, without doubt take the

* *Annuaire des Hôpitaux*, Paris, 1819, p. 494.

first place; then direct blows, powerful pressure, excessive twisting, bending or pulling; to which must be added some other causes, very rare, and each requiring separate consideration.

Falls may take place upon the ends of the feet or of the hands, on the heel or the wrist, on the knee or the elbow, on the hip or the shoulder, on the head or the pelvis; in fine, on almost any part of the body; they may occur from various heights, upon a surface hard or soft, smooth or rugged; or there may be something like a succession of falls, as for instance when a mason, tumbling from a very high scaffolding, strikes a beam, breaks it, and then falls to the ground. Nothing is more variable, more capricious, so to speak, than the effect of falls. There appeared lately in the journals an account of a man falling in a quarry from a height of about twenty feet, without breaking any bones; while a few months ago an old man at Bicêtre, being pitched from the second story, sustained fractures of nearly every bone in his skeleton;—among others such a crushing of the dorsal vertebræ, that the lungs could be removed through the opening thus made. And who does not know that a mere fall on level ground may give rise to fracture of the leg, thigh, arm, or clavicle? It seems generally as if the force of a fall, in order to cause a fracture, needed also a certain action of the muscles, fixing the bones as levers; this is especially marked in fractures by indirect violence; thus it is very difficult to produce such fractures on the dead subject, however we may vary its falls; and the privilege of drunkards, who so often fall with impunity, has become proverbial.

It is certain that many direct fractures are caused by falls; thus a fall on the heel breaks the calcaneum; on the knee, the patella; on the hip, the trochanter; on the shoulder, the cervix humeri; on the chest, the ribs, etc. But perhaps more commonly the part struck remains sound, and the bone is broken at some other point, by counter-stroke; thus by falling on the feet there may be caused fracture of the leg, of the thigh, or even of the pelvis; a fall on the hand may break the radius or the humerus; on the shoulder, the clavicle; or, any one point of the chest being struck in falling, fracture of the ribs may occur at a point more or less distant. The usual theory of indirect fractures of long bones is very plausible; the bone being fixed at one extremity against the ground, the weight of the body acts on the other end, and it is thus subjected to two opposing forces, tending to increase its natural curvature; it then breaks like a bow too forcibly bent. There is doubtless some truth in this comparison; but it must not be supposed that the circumstances always follow this regular plan, and that forces apparently similar, even acting on the same bone, will always break it at the same point, viz., that of its greatest curvature. We see falls on the shoulder break the clavicle at the middle, or near the sternum, or near the acromion. So also the tibia may give way at any point

in its length, though most frequently in its lower half. In the radius, fracture almost always occurs near the wrist. The weakness, natural or acquired, of different portions of bones, the varying obliquity of the fall or counter-stroke, and other circumstances more easily suspected than determined, are probably causes of these differences. The same is true of the form of the fracture, simple, comminuted, or transverse, and of obliquities of direction without rule or measure, quite as impossible to explain as to foresee. To sum up, we can establish the connection of falls with fractures, and form a general idea of their mechanism; but the true theory, which would explain the essential details of the phenomenon, has hitherto escaped our search.

Rude shocks, such as a blow with a stick or a stone, usually cause simple and direct fractures. I have several times broken all the long bones, in the dead subject, with a large iron lever; but have almost never caused comminuted fractures; moreover, and I shall have occasion to revert to this point before long, I have frequently produced only incomplete fractures. Nevertheless, I have seen in the living body bones comminuted by direct violence, when very great; it is thus that a mass of stone, or a beam, or some other heavy body, falling from a height, commonly breaks the bones into splinters; and so also with bodies propelled by gunpowder, as a ball, a biscayen, a splinter from a howitzer, etc. Simple, or rather uncomplicated fractures, are very rare; almost always there are splinters, and fissures extending far from the point of injury.

[A man, æt. about 50, was brought to the Pennsylvania Hospital, in the autumn of 1855, having sustained various severe injuries by the explosion of a blast; he died the next day, and in the examination of the body, a complete comminution of the head of the tibia was found, with merely a slight contusion externally. This could only have been caused by a blow from a fragment of rock.]

Some blows, from the obliquity of their direction, or from the form of the bone, may on the contrary give rise to indirect fracture. Thus a blow on the outer face of the trochanter major produces direct fracture, or even crushing of the bone; a blow on its anterior face would rather cause an intra-capsular fracture of the cervix femoris, which would be obviously indirect. A violent blow on the sternum will sometimes produce a direct fracture of this bone, but it may break, indirectly, the ribs or their cartilages, etc.

Pressure acts in the same way, directly or indirectly, but more slowly; so that the fracture is less sudden, and one may actually measure the interval between the rupture of the first and last of the longitudinal fibres. It is therefore thought that if during that interval the pressure should cease to act, the bone would be but partially broken. This in fact occurs quite often, especially in the ribs; and I have said that in the large bones of the extremities, powerful concussions may produce a similar effect. This theory, then, would indicate that

the rupture occurs by an excessive bending of the bone, and that the fibres on the convex side of the bone during such flexion undergo a severer strain, and should yield first. However, there are some exceptions to this rule. M. Lisfranc has cited a case, to which I shall again refer, of fracture of the external table of the ribs, with flexion inward of the internal table; and I have myself dissected, in an old man, a fracture of the same kind, in which the rib had been bent inward, the convex face resisting, and only the concave surface giving way. (*See Fig.* 10.) I made then upon the sound ribs of this subject some experiments, several of which gave me the same result. I suppose that the fact, thus attested, will not be suffered to go unexplained; but this task I willingly leave to any one who may choose to attempt it.

Under the head of pressure belong bending forces applied to bones in their continuity, increasing or lessening their natural curvature, just as when a stick is bent over the knee. Only, in pressure, the bone is fixed at its two ends, and the force exerted on it acts in the interval; while in the flexion now alluded to the bone is fixed at some one point, and the force exerted on it at one or both ends. A young plasterer, driving his cart along a very muddy road, had put his foot in a deep rut; at the same moment he tried to whip up his horses; the blow missed; he was dragged forward, nearly fell, and had his leg broken by the edge of the rut.* [Might not two forces be said to have acted in this instance on the ends and middle of the bone? The weight of the body would act above; the bottom of the rut would fix the foot, and the edge of the rut bear against the middle of the leg; the latter would be in fact the agent producing the fracture.] In the reduction of old luxations backward of the elbow, more than once the forced flexion of the forearm has broken the olecranon, by the same mechanism.

Torsion acts on the whole extent of a bone, and usually breaks it at its weakest part; it is therefore always an indirect cause. It sometimes assists pressure; thus strong pressure on the sternum fractures the ribs, both by curving and by twisting them. At other times torsion acts by itself; it is the sole cause of many fractures at the lower extremity of the fibula. It may even act on the diaphyses, but there must in such case be either an immense force exerted, or some alteration of the osseous tissue. In this way it often is that patients affected with rachitis or cancer fracture their limbs by turning in bed. While trying to reduce a very old luxation of the femur, I charged an intelligent assistant to rotate the thigh outward at a given moment. The bone resisted this movement, so that the rotation became a torsion, which, though gently made, fractured the femur at its lower third; but the severe and prolonged pains, which accompanied this fracture, would seem to indicate a previous alteration in the bone.

* *Journal Général de Médecine*, tome xxiv, p. 375.

Other fractures are due to violent traction, sometimes direct, as when a limb is drawn in by machinery; sometimes indirect, acting obliquely on the bone, as if to bend it; thus the inner malleolus may be torn off by the eversion of the foot, or the fibula be broken by its inversion. Fractures of the patella by muscular action occur in both ways, but oftener by oblique than by direct traction. I have related, in my Anatomie Chirurgicale, the experiments of Troja and of Wilson, to determine the force with which the bones resist direct traction; thus the ulna of a young man of twenty, stripped of its periosteum, yielded to a force of 464 pounds; that of the opposite side, retaining its periosteum, required a force of 485 pounds. To pull away an epiphysis, the periosteum being intact, 550 pounds were necessary; but 119 pounds sufficed when the periosteum was removed. These experiments, which call for repetition and variation, differ extremely from the results of mere calculation. To cite but one instance; supposing a stout porter, weighing 180 pounds, to carry on his back a load of 1900 pounds, Borelli has estimated the traction sustained by the patellæ as at least 24,960 pounds, which exceeds all probability. I shall content myself with this significant comparison of the results of mere theory and those of experiment.

Muscular action, it would at first seem, could only act by traction on the extremities of a bone, as in the fractures of the patella, already cited. But sometimes this traction acts on the continuity of the bone, the two extremities remaining fixed; and thus are explained certain fractures of the long bones; again, muscular force may act by confining the middle of a bone, while its extremity is raised by a violent motion; thus we see the humerus broken by an effort to plant a blow, to throw a stone, etc. The bones oftenest fractured by the action of the muscles, are the patella, calcaneum, olecranon, humerus, and femur; some analogous instances are related of fractures of the sternum, ribs, clavicle, forearm, and even of the tibia. From what I have seen, it appears to me that there must be either some previous alteration of the osseous tissue, weakening the resistance of the bone, or an abnormal increase of muscular power, as in convulsions and epilepsy; I shall take care to recur to these facts elsewhere, at the proper time and place.

Finally, violent explosions of gas, the sudden disengagement of a mass of vapor, may become causes of fracture, whose efficiency cannot be doubted. Two soldiers had the ends of their thumbs applied over the touch-hole of a cannon; as they rammed down the cartridge, the piece went off unexpectedly; the explosion at the touch-hole was very violent, and one of them had both phalanges of the thumb fractured.* We have even seen, in the terrible catastrophe on the Versailles Railroad, the skull broken all round and splintered

* Ravaton, *la Chirurgie d'Armée*, p. 309.

by the vapor formed in the boiling of the brain; a fearful instance of the power of the agents put in operation by human hands, but which, in such a degree, offers to art only the interest of a sad curiosity.

Such is a nearly complete list of the causes of fractures in the ordinary course of life; but there remains a question much more difficult to approach, viz., how are fractures caused in the fœtus, or in intra-uterine life?

We must at the outset exclude fractures caused in the process of labor, whether by the head pressing into a narrow pelvis, when the skull is exclusively involved, or by the operations of the accoucheur, which act especially on the humerus or femur.* Limiting ourselves, then, to such as occur during pregnancy, there are first those due to direct concussions acting through the abdominal and uterine parietes of the mother.

Devergie has given the history of a woman, who, when seven months gone with child, struck her abdomen severely against the corner of a table. The pain was excessive, and lasted some time. This woman was brought to bed, at the usual time, of a pretty stout child, which had a large tumor in the region of the left clavicle. The child died on the eighth day, and the autopsy showed the tumor to be formed of a solid and voluminous callus, reuniting a fracture of the clavicle; the fragments had somewhat overlapped each other.† The specimen was placed in the museum at Val-de-Grâce, but has unfortunately been lost.

Could a similar cause produce a fracture with projecting fragments? The following fact seems decisive on this point; although I would rather explain it by muscular contraction subsequent to the fracture. A young woman, six months gone, had a fall, striking upon the lower belly; she immediately felt the child move forcibly, but it soon became quiet. She gave birth at term to a very weak and meagre child, having in one leg a transverse wound with pale and flaccid edges; through this wound projected the diaphysis of the tibia, entirely separated from its inferior epiphysis. The projecting bone was necrosed; Carus in vain attempted its reduction, and gangrene destroyed the child's life on the thirteenth day.‡

A more extraordinary case is that of a compound fracture without external violence. A pregnant woman heard, during a movement of the fœtus, a sound like breaking a stick; and from that time she felt in her belly pains as if something was pricking her. Six weeks after, she gave birth prematurely to male twins, one of which had a fracture of the left femur; the bone projected from the integuments more than an inch, and was carious. This fact, which is accredited to Strambio, has received more than one interpretation. Some have

* Chaussier, *Discours pron. à la distrib. des prix de la Maternité*, 1810.
† *Revue Médicale*, 1825, tome ii, p. 152.
‡ *Archives Gén. de Médecine*, tome xvi, p. 288.

seen in it a fracture by muscular action; others, considering the presence of the other fœtus, have presumed that the wounded one had entangled his thigh with his brother's limbs, and broke it in withdrawing it; and Oswald has jumped to the conclusion that such a fracture could not occur but in a double pregnancy.* It is at least prudent to wait for additional facts.

If then so much obscurity involves the etiology of simple fractures, the difficulty is much greater in those singular cases where very numerous fractures exist in almost all the bones of the skeleton. Malebranche says that there was seen at the Invalides, about 1668, a young man, born an idiot, whose bones were all broken at the points where those of criminals are broken; he refers the cause to the mother's imagination, she having wished, while pregnant with him, to see an execution upon the wheel. Hartzoeker, in 1708, relates a similar case, and Muys, in 1751, a third; but neither of them had seen the subjects. A fourth instance was observed by Amand; a lady of quality had an abortion; the fœtus, still-born and apparently at the fourth or fifth month, presented at the middle of the forearms, thighs, and legs, *impressions exactly resembling those made by the iron bar on the limbs of a person suffering on the wheel;* the bones were distinctly divided at these points, and held together merely by the skin. The accoucheur in this case dared not address any questions to his noble patient.†

Monteggia saw also, in a new-born child, twelve fractures still ununited, at the middle of the long bones of the four extremities; the mother had had three severe falls in the course of her pregnancy, a circumstance which would seem to suggest a more plausible etiology; but this experienced observer, struck by the number and symmetry of the fractures, suspected some original defect in the formation of the bones.

But Chaussier has published two cases in which the causes seem entirely beyond detection. The first, and the less complete, was that of a new-born child, left at the Maternité; the mother, so far as known, had met with no accident during her pregnancy, her accouchement had been easy, and no violence had been done to the child. It died a short time after, and the autopsy revealed at least forty-three distinct fractures; some of these were recent, and others more or less united.

The second case was recorded in 1813. A healthy woman, mother of four healthy children, had a fifth pregnancy, and came to her full term without accident; but she remarked that the movements of the fœtus had been rare and slight. The accouchement was easily accomplished in three hours; the child died in twenty-four hours with

* See art. *Fracture* in the *Dict. des Dictionnaires,* and *Archives de Médecine,* tome xvi, p. 444.

† P. Amand, *Observations sur les Accouchements,* obs. 8.

very marked cyanosis; the lungs were very small; the skull, on the contrary, was very large, and contained a great quantity of liquid. But the osseous system displayed the most remarkable lesions. There were counted in it not less than one hundred and twelve fractures, to wit: seventy in the ribs, twenty in the superior extremities, and twenty-two in the inferior. The clavicles, the scapulæ, all the large bones, the fifth metacarpal bone of each hand, and the second metatarsal of the right foot, showed traces of fractures, some yet movable and crepitating, others already consolidated. The long bones of the extremities were evidently shorter, but thicker, than usual, with different degrees of curvature; their periosteum was white and thick, especially at the points recently fractured; the surfaces of these fractures were red, uneven, rugged, and interspersed with little grains and laminated filaments going from one surface to the other. The muscles of the members were thick, folded, and sinuous in the direction of their length.*

To what cause should such lesions be attributed? The old hypothesis, that they are due to the mother's imagination, cannot sustain itself before modern facts; neither could the premature evacuation of the bag of waters, nor the contractions of the uterus on the fœtus, produce such results; and the symmetry of the fractures, which struck Monteggia, is not met with in other observations. Chaussier ascribes them to an internal disposition, an alteration of nutrition analogous to that which renders so frail the bones of old men and some adults, offering as proof the general fragility of the bones, their red color, more marked than normal, and the development of their blood-vessels. This would resemble commencing rachitis; and the equally numerous fractures, seen sometimes in rachitic infants, give some weight to this conjecture. Finally, some have alleged the contractions of the fœtal muscles; and in Chaussier's last case, the hydrocephalus may have given rise to convulsions. It is probable that there may be at the same time alteration of the bones and contractions of the muscles, but this needs clearer demonstration.

* Chaussier, *Mémoire sur les Fractures et les Luxations survenues à des Fœtus*, etc.; *Bulletin de la Faculté de Médecine de Paris*, 1813, p. 301.

ARTICLE II.

VARIETIES OF FRACTURES.

All fractures may be arranged under the following four heads: (1) incomplete; (2) complete, but simple; (3) multiple; (4) complicated.

[It will be seen that this division does not agree with that drawn by American or English surgeons, which, in order to contrast it with this, I will state as follows:—

All fractures are

Simple	or	Compound;
	either of which may be	
	Complete or incomplete;	
(*In long bones,*) Transverse, Oblique, or Longitudinal;		(*In flat bones,*) Fissured, Stellate, or Camerated;

(*In either,*) Comminuted, Complicated, or both;

(*In the bones of the skull,*) Depressed.

The main difference, after all, will be seen to lie in the different signification given to the words *simple* and *complicated*, which the French use as equivalent to our words *single* and *compound*. *Multiple* fractures are not with us considered as a distinct class.]

§ I.—*Of Incomplete Fractures.*

By *incomplete* fractures are meant such as involve only a portion of the thickness of a bone; they are distinguished into two very different species, viz., *fissures*, and *incomplete fractures*, properly so called; to these I would add *splintered* fractures, and *perforations*.

(1.) *Of Fissures.*—The subject of *fissures* or *cracks* having given rise to much discussion among surgeons, I shall treat it at some length, and shall examine it in regard successively to the flat, thick, and long bones.

Among the flat bones, those of the cranium are particularly subject to fissures. They were recognized and described in the time of Hippocrates, and it would be superfluous to quote examples of them. They are not so common elsewhere; but I am not sure that this rarity is not owing to the negligence of pathological anatomists. For myself, I have seen them, more than once, in the fossa infraspinata of the scapula, but always in dried specimens, in which it was

not certain that they had occurred during life. Still, we have other observations showing their existence in the lower maxillary bone, in the ribs, and in the ossa ilii.

A young man, sixteen or eighteen years old, fell from a second story, and died instantly. Among other injuries, M. Gariel discovered at the autopsy, (1) in the lower maxillary bone, at the level of the entrance of the dental canal, on the left side, a complete fracture posteriorly, while anteriorly, beneath the masseter muscle, there was no trace of any solution of continuity; (2) in the left ilium, near its junction with the sacrum, a fracture complete posteriorly, but incomplete on the anterior and inner face of the bone.*

I have before me an os innominatum, which has in its iliac fossa a fissure limited to the internal table of the bone; and another, traversed in its whole thickness by a wide fissure, which descends from the iliac crest across the sacro-iliac facette, to about one-third of an inch from the sciatic notch. These two bones certainly belonged to adults; unfortunately I have not their previous history. Gulliver says he has seen an incomplete fracture of the pelvis, in a child run over by a carriage-wheel; it was probably a simple fissure.† Lastly, the following clear instance of fissure of a rib was observed by M. Lisfranc.

A young girl, aged 15, was thrown down by a cabriolet, the wheel of which passed obliquely over the right side of the thorax; she died the next day. The autopsy disclosed, besides various other lesions, a fracture at about the middle of the first rib on the right side, involving its whole thickness; in the second rib an incomplete fracture involving both the anterior and posterior faces of the bone; in the third, *a longitudinal fracture between one and two inches in length, occupying the lower edge of the bone;* the fourth and fifth had sustained fracture of their external tables, with considerable flexion, while in the sixth the external table was broken, and the internal one merely bent.‡

Among the thick bones, fissures are infinitely more rare. Gulliver says that there is, in the Museum of the College of Surgeons at Edinburgh, a patella having a transverse fissure on its articular face, without any corresponding mark anteriorly. I have, and have had drawn, (*see Fig.* 79,) a specimen of the same kind; but a careful examination showed me on the external face a transverse depression, seeming to indicate a complete fracture without notable displacement. Perhaps the same is true of the patella at Edinburgh. I have also seen, in a specimen sent me by M. Voillemier, the head of the humerus traversed by two or three pretty deep fissures, without

* *Bulletins de la Société Anat.*, 1835, p. 24.
† *Gazette Médicale*, 1835, p. 472.
‡ *Nouvelle Biblioth. Médicale*, July, 1828, p. 42.

any external separation. (*See Fig.* 23.) Lastly, Palletta has given an account of a fissure observed in a vertebra, which will be of some interest here.

A man, aged 35, was pulling with all his strength at a rope, to bring down a tree; suddenly he lost his equilibrium, and fell down with violence; by the shock, the whole lower half of his body was paralyzed, and on the eleventh day he died. At the autopsy blood was found in the pleuræ, as well as among the muscles of the back. Raising up the anterior vertebral ligament in the thorax, the third dorsal vertebra was seen to be cracked from above downward, with detachment of part of the external layer of its body. Opposite the fissure, the medulla spinalis was narrowed as if compressed by a band, and its membranous sheath seemed empty and flaccid. It would seem, from this account, that the fissure was limited to the body of the vertebra; I regret, however, that Palletta has not expressed himself more precisely.*

There remain yet fissures of the long bones, or rather of the diaphyses; and it is on this point that the discussion has been most active. Felix Wurtz has devoted to them one chapter of his book, but without citing any instances. In 1686, Stalpart Vanderwiel published, under the title of *Fissure of the Tibia*, an account of a servant wounded in the leg by the kick of a horse. The wound cicatrized, but the pain continued; a surgeon, suspecting fissure, trepanned the tibia, and the patient recovered. As it is not stated whether or not the diagnosis was confirmed, there is still room for doubt in regard to it.

J. L. Petit, not troubling himself with antecedent facts, denied the possibility of fissures of the long bones, because, said he, a blow sufficient to fracture the bone in its length, would break it across much more readily. Duverney, however, collected several new instances, which, being opposed to the opinions of the school, were rejected with great disdain. I shall not stop to examine the strange criticisms passed upon them by Louis; but they amount to this peremptory argument, that in neither instance did fissure exist, because fissure was impossible.† Not only is fissure of the long bones very possible, but we have examples enough of it to study it in a satisfactory manner.

In the first place, it has already been observed in most of the bones of the extremities; but most frequently in the lower limbs, and in the tibia oftener than in the femur. There are two fissures of the tibia in the Musée Dupuytren; one without any history (No. 699;) the other, (No. 221,) presented by MM. Marjolin and Rullier,

* Palletta, *Exercitationes Patholog.*, Mediolani, 1820, p. 236.

† Louis, *Discours Préliminaire du Traité des Maladies des Os, de J. L. Petit*, 1758, p. 105, et seq.

was struck by a ball, the impression of which may be seen on its inner margin. To these may be added Duverney's two cases, and three others, due to Bécane, Léveillé and M. Campaignac.

As to the femur, M. J. Cloquet has figured a case, complicated indeed with a perforation of the bone. A Russian soldier, in 1814, had the femur traversed by a ball from before backward, above the condyles; he died of hospital gangrene; at the autopsy there was found, besides the clean-cut perforation made by the ball, a fissure separating the two condyles, and passing up nearly to the middle of the bone.* But the finest possible example of pure unmixed fissure, is doubtless the one I have had drawn from a specimen given by Fleury to the Museum at Val-de-Grâce. (*Fig.* 1.)

In the upper extremity, I know of but one case in the humerus, and another in the ulna. The former is reported by Campaignac, to whom it was communicated by M. Ripault. A boy, eleven or twelve years old, had the forearm drawn in by the wheel of a machine, the arm being also so mashed as to require the immediate performance of disarticulation of the shoulder. The humerus was found split lengthwise, and the fissure, directed from without inward, involved the entire thickness of the bone; it began toward the inferior extremity, above the tuberosities, and ended at the insertion of the deltoid; its edges were separated, especially below, so that the blade of a knife could be passed in between them.

The other example, cited by Chaussier in his lectures, occurred in a criminal, forty years old, who died a few hours after being tortured; the autopsy revealed, in the upper fourth of the ulna, a linear fracture directed obliquely toward the articulating extremity, and limited to the middle of the thickness of the bone.†

We see that all these cases concern subjects between twelve and forty years of age, that is to say, from adolescence to adult age. The causes are exactly the same as those of other fractures; violent shocks, gun-shot wounds, whether the ball lodges in or traverses the bone; strong pressure; in one case reported by M. Campaignac, a simple fissure was caused by a fall. A woman, aged 38, threw herself from a second-story window, and died instantly. The left tibia presented in its superior third four longitudinal cracks, one anterior, with an oblique and tortuous course, extending from the middle of the internal articular cavity as far as the upper edge of the external face of the bone, four and one-third inches below the joint; another situated on the inner face, and two posterior, nearly vertical, parallel to one another, distant from the other about one inch, not reaching up to the articular surface; these three cracks were each about

* J. Cloquet, *Thèse du Concours de Pathol. Externe*, 1831, pl. xii, fig. 7.
† Chaussier, *Médecine Légale*, p. 447, et seq.

two inches and two-thirds long, and showed no separation; but the anterior one gaped slightly, especially above.*

These fissures are rarely single; generally there are several, of various extent and depth. The smaller do not reach the medullary canal; I convinced myself of this by examining the specimen at Val-de-Grâce; the larger occupy the whole thickness of the wall, but do not leave a notable separation between their edges. If, on the contrary, they traverse the whole thickness of the bone, which only occurs when they reach one of its edges or extremities, then there may be a separation of one-thirtieth to one-fifteenth of an inch, as in the cases of MM. Ripault and J. Cloquet.

It will be seen that even with this separation, it is nearly impossible at once to diagnose a fissure, unless an external wound exposes it to view. It is, therefore, only from its consecutive phenomena that one can suspect its existence; but the gravity of the injury then calls for all the attention of the surgeon.

It is to be regretted here, that surgeons have not left us more complete observations; we see, indeed, that fissures have always involved death, or at least such danger as could only be avoided by an operation; but the nature of the accidents has not been sufficiently explained. The patients of Bécane, of Léveillé, of M. J. Cloquet, died. Duverney speaks likewise of a surgeon of Paris, who fell a victim to a fissure of the tibia, recognized too late; and the specimens in our museums, the histories of which we do not know, indicate by the recent state of the fissures that the limbs were soon lost. At least the known facts show very clearly how cautious must be the prognosis, whenever fissures are suspected, however slight the injury may at first seem. Bécane's patient had received a blow with a hammer on the middle of the tibia, which did not hinder his walking afterwards; but *he met with several other accidents*, and finally died, when the tibia was found split for a length of about three and a half inches.† Léveillé's case is still more striking. An Austrian soldier had received, at Marengo, a ball in the inferior third of the leg. He nevertheless went on foot several miles, to Alexandria, whence he was carried to Pavia. The wound seemed simple enough, and only to require the exfoliation of the portion of bone touched by the ball, in order to cicatrize. This did not occur, and amputation of the thigh became necessary. Dissection showed in the tibia, beginning from the impression of the ball, several longitudinal and oblique lines, which reached from the lower third to the femoral extremity of the bone; they were fissures involving the whole thickness of the bony wall, into the medullary canal.

* Campaignac, *Des Fractures Incomplètes, etc.; Journal Hebdomadaire*, 1829, tome iv, p. 115.

† Bécane, *Abrégé des Maladies qui attaquent la Substance des Os;* Toulouse, 1775, p. 134.

Duverney's observations, the most complete yet possessed by science, will not be out of place here.

A canon fell from a height, striking the middle of his left leg; great pain, ecchymosis, and swelling ensued; bleeding and topical remedies allayed these symptoms in a few days; he thought himself well, and acted accordingly. "When going to bed, he perceived a redness on the anterior part of this leg, and some tension also. In the course of the night he was attacked by pain, so excessive that he could not bear it. It was determined to make an incision down to the bone, at the most elevated point of the swelling; from this issued a sanguinolent serosity, apparently from between the periosteum and the bone, the former being detached for more than two fingers'-breadths. It was easy to see whence these symptoms arose, *since there appeared a very extensive longitudinal fracture;* the incision had to be enlarged each way; and the patient was much relieved. To hasten the cure, and avoid the accidents to be feared in cases of this sort, recourse was had to the perforating trephine and exfoliator, with success, as the fissure did not penetrate to the medullary canal. The patient was cured in less than two months."

Here the crack was slight, and merely caused a stripping off of the periosteum, perhaps with some superficial alteration of the bone. In the second case, the fissure reached the medulla, causing it to suppurate.

A *garde-du-corps* received a kick from a horse, on the middle of his left leg. The very acute pain he felt at the moment was gradually succeeded by a numbness so great that he could not move the leg. Topical applications were made; the skin became gangrenous; nevertheless, the wound soon healed. Three months afterwards, there suddenly came on a pricking pain, which prevented his attending to his duty. After trying various remedies, it was resolved to lay bare the bone. "The incision being made, the bone appeared of a brown color, somewhat raised, and with *a very evident fissure, quite long and deep.*" The wound was enlarged upward and downward; dry dressings were applied, and the next day the superfluous bone was removed with the gouge and mallet. Pains recurring in the shaft of the tibia called for the reapplication of these instruments; at the last few blows there issued from the fissure a yellowish and very putrid liquid; and the pain was at once allayed. At the following dressing three crowns of the trephine were applied, and the disks of bone extracted; the medulla was found to have suppurated. Four months sufficed for a complete cure.

From all this we see that the symptoms are no other than those of contusion of the bone, so well studied by Ravaton, and that they depend sometimes upon periostitis, sometimes upon suppuration in the medullary canal; which explains at once their slow development, and their gravity, yielding only to trephining of the bone. The

fissure itself is but a slight affair, and it is presumable that more prolonged rest, and a more persevering use of antiphlogistics, would avert all danger. Probably more than once fissures have even been thus cured without being recognised; and this consideration is to be added to those which should awaken the attention of practitioners to this subject.

(2.) *Of Incomplete Fractures, properly so called.*—I give this name to such fractures as, involving a part of the thickness of the bone, are accompanied by more or less flexion of the portion still resisting; this has been called *depression* in the flat bones, *curvature* or *traumatic flexion* in the long.

The actual existence of these fractures has been denied, for various reasons. Some would regard the bending of bones without breaking, as impossible; others, on the contrary, assert that there may be simple curvature, and no fracture at all; the question is still under debate.

Thus, as regards the flat bones, the surgeons of the last century admitted depressions of the cranial bones, and of the ribs, without fracture. That the yet soft bones of a new-born child can be thus depressed, I know from my own experiments; but I never have been able to cause permanent depression, except by breaking the bone at several points. Sandifort has figured in his Museum the two cases most applicable, at first sight, to the support of the doctrine of simple depression in the cranial bones. There is represented, first, the skull of an infant, whose head, a very large one, was tightly wedged in a cuneiform pelvis. Soek, an expert accoucheur, succeeded in saving both mother and child; but the latter had sustained a great depression of the skull, which resisted all remedial means, and it died at the end of four weeks. This depression involved the right parietal bone, extending from the lambdoid suture as far and even farther than the centre of the bone, a distance of two inches (fifty-four millimètres;) its depth was the same, and it was limited below and in front by a rounded border. But at the bottom of the depression, and especially at the anterior portion of the bone, was a fracture an inch and one-third (four centimètres) long, reaching to the fontanelle, and already filled with reddish bony matter.

Another child, likewise delivered by Soek, and this time still-born, showed a similar depression of the right parietal bone, and of the neighboring portion of the frontal. This depression was fourteen lines (thirty-one millimètres) in depth; but two fissures were seen near the coronal suture, one in front, already united, and one further back, closed by a membrane.*

These depressions are by no means rare in the ribs, even in old men. There is shown (*Fig.* 10) a depression in the sixth rib from a

* See *Sandifort's Museum*, tab. xxxiv, figs. 1 to 5.

fracture limited to the external table; much oftener it is the internal table which breaks, and there is generally at some other point another fracture, complete or incomplete. I shall refer elsewhere to this important variety of fractures of the ribs.

As to the other flat bones, I can cite but one example of incomplete fracture with depression, which occurred in the scapula. A laborer was working in an excavation, with his back bent, when a mass of building-stone weighing ten kilogrammes [something over twenty pounds avoirdupois] fell a distance of about fifteen feet, striking upon his left scapula. He was knocked down by the blow, but got up; the pain caused by moving the arm preventing him from resuming his work, he came to consult me. The skin was severely contused toward the centre of the scapula; pressure on this point gave pain, and the finger sunk into a very marked depression, limited internally by a sharp osseous ridge, and externally rising gradually to the level of the rest of the bone. The scapula moved *en masse*, without any crepitus. I judged, therefore, that there was an incomplete fracture, with depression, in the fossa infra-spinata. It was impossible to replace the depressed portion, and I contented myself with binding the arm to the chest by a bandage, till the pain should cease.

In all cases, in fact, when a depression of this kind is merely painful, the simple indication is to assuage the pain by rest, and by antiphlogistics if necessary; and this is true of fracture of the skull and of the ribs, as well as of those of the scapula. If the depressed fragments should cause graver symptoms, as for instance if they should penetrate the viscera, it would become necessary to elevate them. Hence, one indication for trephining in wounds of the head; and I shall speak elsewhere of the means of relieving depression of fractured ribs, generally without any operation.

I do not know that similar fractures have been observed in the thick bones, although I would by no means pretend to deny their possibility. There has indeed been diagnosed an incomplete fracture in the cervix femoris, the structure of which much resembles that of the thick bones. Adams, in 1834, read to the Surgical Society of Ireland a paper on this subject; but I apprehend he mistook extra-capsular fractures, with impaction, for partial fractures.* The following observation, published by M. Tournel, seems to me to be of more value.

An old man of eighty-five, thrown down by a drunken comrade, fell on his buttocks, and could not rise; he was taken to the hospital. No shortening or crepitus was detected; but he complained of very acute pain, increased by the least movement, in the upper part of the thigh; he could not raise the whole limb at once, and the soft

* *Gazette Médicale*, 1835, p. 641.

parts about the hip-joint were considerably swollen. An intra-capsular fracture, without displacement, was suspected, and the long splint of Desault was applied. On the twenty-eighth day, the limb being of its normal length, and the pain being gone, M. Tournel thought the case had been one of mere contusion; he therefore ceased making permanent extension. But, fifteen days later, the shortening reappeared, the foot was everted, the thigh slightly arched upward; the limb was placed on a double inclined plane; the patient was, however, soon after seized with diarrhœa, and died three and a half months after his fall. The autopsy disclosed an incomplete fracture between the base of the neck and of the trochanter major, constituting a long fissure, which from the digital fossa, internal to this trochanter, descended before and behind to a little below the trochanter minor; the latter being attached to the inner fragment. It was, therefore, intra-capsular above, extra-capsular below. Below the trochanter minor was a sort of osseous bridge, which had resisted the fracture. The surfaces were not immediately in contact, but joined at the upper part by a reddish bony matter interposed between them, solid enough to hold the two fragments together.*

There remain to be examined incomplete fractures of the diaphyses, which are not much better known than the others. Since 1673, dissection has placed the fact of their occurrence beyond doubt. A child, twelve years old, in jumping, felt a pain in his thigh. He could, for two days, walk and go down stairs, putting the point of the foot to the ground; after which there ensued an acute inflammation, and a copious suppuration, which carried him off. Glaser made the autopsy, and among other injuries found a fissure extending *both longitudinally and transversely.*†

This observation remained isolated for nearly a century, and incomplete fractures were still regarded as impossible, when, in 1765, Camper, writing to the Edinburgh Society, asserted that they were not rare, giving a representation of a tibia affected with such a fracture, easily to be recognised in spite of consolidation. The fracture was on the anterior surface, near the middle of the bone; it had left a linear impression in the form of a finger-nail or a scale, so that Camper gave it the name "squamous fracture."‡ The tibia had preserved its normal straightness; and it would not appear that in Glaser's case the femur had undergone any shortening. But, lastly, A. Bonn published a third case in which the bone remained curved; it was the femur of a robust adult man, curved backward by external violence; the posterior face still presented the marks of the

* *Archives de Médecine*, 1837, tome xiv, p. 77.

† Th. Boneti, *Sepulchretum*, Lugd. 1700, tome iii, p. 424.

‡ *Essays and Obs., Physical and Literary, of the Edinburgh Society*, vol. iii, 1771, p. 537.

fracture, such as thickening and inequalities; the anterior face had remained intact, and offered only a simple concavity, smooth and polished.*

Thus, curiously enough, pathological anatomy has thrice decided the question, but theory still resists; and when finally observations were made on the living subject, it was deemed preferable to believe in simple curvatures of the bones than in incomplete fractures. They are thus designated in the Thesis of Thierry, the earliest analytical work on this subject which I know of; the author had seen the following two cases.

A child of ten years, having fallen from a horse, felt an acute pain in the right forearm. Thierry being consulted, found the forearm in a state between pronation and supination, and presenting a marked concavity on its posterior face, an equal convexity existing in front, so that it represented the arc of a circle; there was neither mobility nor crepitation; the first phalanges were extended, the rest flexed. The surgeon had strong extension made, while he compressed the prominence; thus he restored the straight form of the arm; he applied a simple bandage, and at the end of twelve days the child was cured without either deformity or swelling of the bones. The other observation referred to a child, seven years old, who fell from some height upon the right forearm; the symptoms were similar, and the cure took place likewise in twelve days.†

Thierry at the same time cites A. Dubois as having seen analogous cases; nevertheless, these remarkable facts went unnoticed until, in 1820, a medical journal called attention to the subject, by publishing an observation dating from the year 1771. It was as follows.

A little girl five years old, being mounted on an ass, fell off on the gravel. The left forearm was found completely bent at its middle, but without crepitation. The surgeon pressed pretty firmly, and in different directions, on the prominence formed by the curvature of the forearm; the child declared that it felt nothing piercing it, though otherwise the pain was considerable. Moderate extension restored the straightness of the bones, and from these facts Chevallier concluded that the case was one of a simple bending.

Now at length the subject was taken up; and Jurine, of Geneva, addressed to the same journal a note, in which the question assumed an entirely new aspect.‡ "Accidental bending of the bones of the forearm," wrote he, "is not very rare; in the course of forty years I have treated twenty cases of it, and have seen it occur twice at the same point in the same individual. It takes place more frequently in young persons than in those of riper age. According to my observations, the scrofulous are more liable to it than others,

* A. Bonn, *Descript. Thes. Ossium Morb. Hoviani*, 1783, No. 185.
† Pierre Thierry, *Thèse Inaug.*, Paris, an xiii, No. 349.
‡ *Journal de Corvisart et Boyer*, tome xx, pp. 278 and 499.

from their tendency to rachitis; it is the result of a force acting in the longitudinal direction of the bones. Both bones yielding at once, and always in the outward direction, the arc described by their curvature has different degrees, according to the amount of the force; but these degrees have certain limits. It is toward the inferior third of the forearm that the greatest bending takes place; I have never seen it exactly at the middle. . . . These curvatures are not followed by any troublesome symptoms, at least I have met with none."

He has thus seen the humerus bent forward and a little inward, in a child seven years old; and in another child of about the same age, he has seen the lower third of the leg bent, like the forearm, but to a less degree.

But what is most remarkable in the observations of Jurine, is the difficulty of reduction. "The first time I was called upon to treat this accident," says he, "I made continued extension, pressing strongly on the angle of the bones, and by this means I diminished the curvature, without succeeding in entirely effacing it. The apparatus I applied was very simple; it consisted of a splint three inches wide, placed along the concave face of the forearm, and maintained there by a bandage reaching from the fingers to the elbow. At the end of a month I had obtained, by means of this compression, a diminution in the arc of the curvature. I now left off the bandage, so as to give liberty to the muscles, not doubting that the forearm would always remain slightly curved, as it then was; but I was agreeably surprised by seeing it resume insensibly its natural appearance; which I could not but attribute to the effect of muscular action, or rather to the reaction of the compressed bony fibres. After six months it was very difficult, and at the end of a year impossible, to say which had been the affected forearm."

"All the patients treated by me for this injury have been similarly affected, and the result has been nearly the same; in a single case in which the curvature was less, I used merely the splint and bandage, and the cure took place equally well."

The assertion of Jurine concerning the frequency of these fractures is somewhat surprising, when we consider the silence of most authors in regard to them, and the small number of cases published. Mr. Hart says that he has seen five cases within the space of three years; and Johnson adds that he has himself met with eight others; but the other observers who have spoken of it, MM. Champion, Wilson, Pourché, Campaignac, J. Cloquet, and Gulliver, have seen this lesion but once; it is recorded but once on the registers of the Hôtel-Dieu for the eleven years examined by me; and, lastly, I have myself seen but one example.*

* See for these several cases, Hart, *Partial Fracture of the Long Bones in Children, Medico-Chirurg. Review*, April, 1832, p. 588; Champion, *Observa-*

But, on the other hand, the facility of its production in the dead subject is to be thought of, and lends strong support to the assertion of Jurine. M. Campaignac succeeded, in 1826, in half breaking the tibia and fibula, by fixing the leg in a vice and forcibly bearing the foot outward. Its occurrence in this manner is rare; for my own part, as I have already said, I have used a direct blow by means of a large iron bar, and have obtained partial fractures in all the long bones of the extremities, not only in young, but in old subjects. Some skeletons seem absolutely to resist fracture of this kind; the bones of the forearm sustain it most readily; the femur and tibia least so. But I have so often succeeded, that it has occurred to me to inquire how it is that these incomplete fractures are so rare in practice; and whether they often pass undiagnosed, or, immediately after the blow, are made complete by muscular contraction or by a consecutive fall. Besides, these fractures, in a manner artificial, present all the phenomena observed in the living body—the bending at an angle, easy to overcome in some cases, but in others impossible, from the impaction of the serrations of the fractured portion. One can get a very good idea of this from *Fig.* 2.

We see, then, that so far, whenever the state of the bones has been examined, whether after experiments or in autopsies, incomplete fractures have always been found; never simple curvatures. I am aware that something may likewise be said in support of the doctrine of mere curvatures. It is very true that Dethleef, believing he had broken both bones in a dog's leg, found the fibula bent without fracture. Similar results were obtained by Duhamel in a lamb, and by Troja in a pigeon. I have twice succeeded, myself, in bending the fibula and breaking the tibia. The possibility of mere curvatures is then indisputable; but it must be remarked that as yet they have only been obtained in young animals; that they have only been permanent by reason of fractures with displacement occurring in their vicinity; and that they differ widely from the curvatures believed by some to have been seen in man, in which the bent bone remained so of itself, resisting reduction even as far as complete fracture.

[See an excellent article by Dr. John Rhea Barton, published in the *Philadelphia Medical Recorder*, for 1821; this is stated by Dr. Norris (Am. edition of Fergusson's *Practical Surgery*) to be the first English essay on this subject. See, also, an article by Dr. F. H. Hamilton, of Buffalo, N. Y., published in the *New York Journal of Medicine* for Nov., 1857.]

The nature of the lesion being thus placed beyond doubt, let us seek, by the aid of known facts, to trace more exactly its history.

First, it is in the bones of the forearm that it most commonly

tions, etc. in the *Journal Complémentaire*, October, 1818, p. 325; Wilson, *Lectures on the Bones and Joints*, 1820, p. 199; Campaignac, *loc. cit.;* J. Cloquet, *Thèse du Concours*, 1831, pl. xii, fig. 11; Gulliver, *Medical Gazette*, 1835, p. 472.

occurs. Setting apart the observations of Jurine, it has been seen by Chevallier, Thierry, Wilson, Otto, Gulliver, M. Champion, and myself, only in the forearm. Are both bones always involved? According to Gulliver, there is in the Museum of the Royal College, at Edinburgh, an incomplete fracture of the ulna. Hart says that he has twice seen it in the radius alone. The same may have been the case in my patient; and I have assured myself, by experiments on the dead subject, that the bending backward of the radius marvelously resembles that of both bones. At the same time, when the angle nearly reaches 90°, the ulna generally participates in forming it; and in a case of this kind, Wilson actually found, at the autopsy, that both bones were involved.

Next to the forearm comes the thigh. To the two cases of Glaser and Bonn, already mentioned, may be added a fracture of the same kind in the femur of the rachitic skeleton, No. 516, in the Musée Dupuytren; moreover, Hart claims to have twice seen it during life, and Johnson likewise twice.

The leg has afforded nearly as many examples as the thigh. Jurine mentions one case; Johnson says he has seen the tibia thus fractured; and, besides the specimen figured by Camper, we have another case of an autopsy communicated by M. Pourché to M. Campaignac, in which the lesion was likewise limited to the tibia. This makes four cases, to which may be properly added two incomplete fractures of the fibula, ascertained by an autopsy by MM. Campaignac and J. Cloquet.

Lastly, Jurine and Hart each appear to have once observed incomplete fracture of the humerus, and Johnson twice that of the clavicle; so that all the long bones seem to have furnished their contingents to this variety of fracture.

Age has here a remarkable influence. It is in infancy that these fractures have been nearly always observed; but not, as one would presume, in the earliest period. Of fourteen subjects whose ages are stated, I have found but one of ten months (Hart) and one of three years (Wilson.) All the rest are comprised between five and thirteen years. The cases of Camper, Bonn, and M. J. Cloquet, seem to have occurred in adults. Jurine plainly states that he has seen it in mature age, and my own experiments sufficiently prove its possibility at any period. Girls would seem to be no more liable to it than boys.

The causes are the same as those of complete fractures. Sometimes they are indirect, and it may be noted that the majority of incomplete fractures of the forearm were thus produced by falls on the hand, the wrist being bent either forward or backward. Sometimes they are direct; resulting from a blow, or from strong pressure. It is remarkable that causes of this kind prevailed almost exclusively in incomplete fractures of the lower extremity.

The symptoms are very variable. Generally the bone is more or less curved, the angle being always salient on the side of the fracture; and this curvature can be diminished by sufficient pressure, but rarely entirely overcome, from the irregular interlocking of the serrations of the fracture. In Gulliver's case, a month was required to restore the forearm to its natural form. It appears, however, that sometimes perfect reduction can be immediately performed, if, indeed, the cases admitting of this were really cases of incomplete fracture. Lastly, at other times the fracture occurs without separation or curvature; the only sign of it is then the bending of the bone under pressure with the finger at the point involved. Yet we see this same symptom attend complete fracture in the living subject, when simple and without displacement; but here the error in diagnosis would be unimportant.

The treatment consists, first, in obtaining reduction. For this, extension is entirely useless; the only rational means being moderate pressure on the salient point until it is caused to disappear. A bulky member, such as the leg or thigh, should be extended on a solid plane, and the pressure made with the palm of the hand or with the wrist; in the forearm, especially in young patients, we may grasp one end of the bone in each hand, bearing on the angle with the joined thumbs, as if to bend it in the opposite direction. If the curvature do not entirely disappear, it is prudent to wait, applying a compressing apparatus; but if it still persist after several days, it must be overcome at all risks, even, as has occurred to me, by rendering the fracture complete. If there be neither separation nor curvature, the diagnosis always remains very uncertain. In case of doubt, we should proceed, without any previous manipulation, to apply the apparatus.

This should be very simple. When compression is required, one splint should be placed above, and one below; both should be of the length of the bone involved, padded to protect the integuments, and retained by a roller. Reduction being once complete, a simple splint and roller are sufficient, or a starched or dextrinated bandage.

The time necessary for consolidation is the same as for complete fractures. Thierry and Hart left off the apparatus at the end of twelve days. With young subjects, and in the forearm, such haste may give rise to no bad consequences; yet it seems to me to expose our patients to the double danger of a recurrence of the fracture, and of those pains often caused by imperfect formation of callus.

In fractures of the lower extremities, to commit the weight of the body to bones half fractured and but half united, would be a far more dangerous imprudence; and so much the more, as there is no harm in waiting a little longer.

The following is the history of a case in which I adhered to this rule:—

A little girl of eight years, strong and well proportioned, was running in one of the courts at Bicêtre, when she was tripped up by some obstacle, and thrown against a door, her right hand forward, but flexed, so that its dorsal surface struck the door. She likewise lost her balance and fell on the ground, still on the same hand. Curiously enough, she felt no pain; so that it could not be determined at which moment the bending had taken place. But when she rose up, the forearm was bent backward, at about the middle, nearly to a right angle. M. Verjus, my interne, was called at once, and, thinking he had to deal with a fracture of both bones, attempted its reduction. He brought the forearm to an angle of 160°, but no farther; or, at least, when the pressure was removed which had given it its right form, it at once resumed this curvature. It must be added that, in commencing the reduction, there was perceived a slight crepitus; but it could not be reproduced afterwards. I saw the patient the next morning. The angle remained at 160°; there was neither mobility, projection of the fragments, nor crepitation; the forearm could even be pronated and supinated. No pain except on pressing at the highest point of the curvature. During three days things remained thus. Finally, on the fourth, the pain having disappeared, I tried to obtain complete reduction, and succeeded with the radius; but I perceived at once a mobility at the level of the effaced angle, denoting positively a complete fracture. The ulna was as solid as before. I applied the ordinary apparatus, and the cure was complete by the twentieth day.

(3.) *Of Splintered Fractures.*—I mean by splintered fracture the complete separation of a mere splinter, leaving the bone itself nearly solid. Fractures of this kind are usually caused by a cutting instrument, as by a blow with a sabre; sometimes, also, a ball, grazing a bone, does not quite break it; in either case, there must inevitably be the complication of an external wound. Instances of this kind are mainly seen in the skull, where they have been called, in Latin, *dedolatio*, in Greek, *aposkeparnismos*. They are more rare in the bones of the trunk and extremities. Still, cases are given of ablation of larger or smaller portions of the facial bones, and of fractures of the extremities of the spinous apophyses of the vertebræ. M. Fauraytier has shown me a femur in which a ball had carried off the base of the trochanter; an exuberant callus had more than repaired the loss of substance which resulted without there being any other fracture, and a fibrous cord, extending from the orifice of entry of the ball to the bone, showed plainly enough the direction of the wound. M. Paillard mentions an officer who at the siege of Antwerp had part of the calcaneum carried away by a grapeshot.* Ravaton has given a case of a sabre-cut separating the lower extremity of the

* Dupuytren, *Traité des Blessures par Armes de Guerre*, tome i, p. 338.

ulna. Other ablations of splinters, more or less important, have been observed in the elbow and knee, but we see that the spongy tissue is always concerned; as to the compact portion, I know of but one case, also given by Ravaton, of a sabre-cut which, being inflicted on the middle and outer part of the right leg, carried off part of the spine of the tibia without injuring the rest of the diaphysis.*

Could similar fractures be caused by external violence without any lesion of the integuments? Undoubtedly, in some of the flat bones; it is not excessively rare to see a portion of the crista ilii detached by a severe blow. In fracturing the ribs in the dead subject, I once succeeded in scaling off the lower border of one rib, the rest of it remaining unbroken. But what would seem to surpass all belief, is that mere splinters have been detached from the middle of a diaphysis, as of the femur, by external violence which could not have produced a wound, reunion of the splinters having occurred. Sandifort has had drawn two specimens of this kind, unhappily without knowing the history of the subjects; but at sight of the plates there remains no doubt of the nature of the lesion he describes. One would call it the incomplete fracture of Camper, carried as far as total detachment of the splinters; beyond this, laying aside all conjectures, I shall confine myself to translating literally the text of Sandifort.

"No. 310.—Femur of the left side, in which is seen, projecting from the middle of the diaphysis, a splinter, an inch and a half broad, apparently detached from the external surface of the bone by violence from without, and but partially reunited to the diaphysis.

"No. 311.—Femur of the left side, having, like the preceding, a splintered fracture at about the middle of its diaphysis. From its external face is separated a lamella, four inches long, which posteriorly is reunited with the bone in nearly its whole length, but only to a slight extent in front. Above, it is fused with the bone; below, it is separated for a length of two and a half inches, the interval amounting to three lines," [between one-quarter and one-third of an inch.]

The treatment of a splintered fracture with a wound is very simple. If the splinter is small and unimportant, it hinders healing, and should be removed; even if larger, it should be removed if its connections with the soft parts are too slight to afford hope of its reunion. In any other case, it should be replaced along with the soft parts, and an attempt made to obtain immediate consolidation. If, perchance, a simple splintered fracture is detected in the living subject, without any open wound, it will at most be only necessary to apply a roller to keep it in place; but in the large bones of the extremities, rest is essential to complete consolidation.

* Ravaton, *La Chirurgie d' Armée*, pp. 619 and 630.

(4.) *Of Perforations.*—The name alone suffices to give an exact idea of these lesions; it implies, strictly, that the bone is perforated through and through, or in one portion only of its thickness, by a foreign body; whence it follows, first, that every perforation is attended by an external wound; and, secondly, what is very important, that the foreign body may or may not remain lodged in the bone.

The agents producing perforations are penetrating instruments; swords, knives, lances, etc., or bodies propelled by gunpowder.

Sword or lance wounds, penetrating the facial bones, are not rare; I will here only recall the severe lance-wound which was received by the Duc de Guise before Boulogne, and which earned him the name of Balafré (gashed.) The bones of the skull are more resisting, and more liable to fractures with depression than to perforations from thrusts. Desport, however, relates the case of a journeyman tailor who had the right parietal bone pierced by a pointed bit of wood falling from a height; it was necessary to trephine, to extract the foreign body, which, after penetrating as far as the brain, had broken off at the level of the bone. Percy, quoting this account, adds to it that of a servant at an inn, who had a large knife driven into the frontal bone by a drunken soldier. Ravaton also saw a slater killed by a blow with the point of his hammer, which had deeply penetrated the skull The vertebræ, though thick and spongy, have been more than once perforated in this manner; Percy reports the case of a grenadier wounded with a foil, the point of which was driven into the body of the fourth dorsal vertebra. Two centuries before this, Fabricius Hildanus had extracted for a young man half the blade of a long knife, buried for two years between the bodies of his third and fourth lumbar vertebræ. Ravaton has seen a sword-wound penetrate the scapula, and the sternum; lastly, notwithstanding their narrowness, the ribs have sometimes sustained such perforations; Percy witnessed the extraction of a sword-point, broken off in a rib; and every one knows the far more celebrated case of Gérard, preserved in La Faye's notes upon Dionis;* the blade of a knife having pierced the rib and penetrated an inch into the thorax, was broken off on a level with the outer surface of the rib; the adventurous surgeon divided the intercostal muscles, and introducing his finger armed with a thimble into the thorax, pushed out the broken bit of the blade by pressing on the point. Cases might also be cited of perforation, by pointed weapons, of the spongy bones of the foot and hand; but it can hardly be conceived to be possible in the diaphyses, and I know at present of but one instance, in which

* [*Cours d'Opérations de Chirurgie.* Par M. Dionis. Fourth ed., with remarks, etc. by G. de La Faye. Paris, 1740.]

Ravaton had occasion to extract a sword-point half an inch long, buried in the middle and outer part of the femur.*

Perforations by balls and other projectiles are much more frequent, and more varied in character. I shall not dwell much upon complete perforations of the cranial bones, of the sternum, vertebræ, and pelvic bones; it is very rare in such cases for the ball, in its subsequent course, not to so injure more important organs as to either produce immediate death, or to give the surgeon more serious cause for concern than the mere lesion of the bone. But incomplete perforations present varieties which it is interesting and important to study.

Gockelius, as quoted by Percy, relates that a ball, striking the frontal bone, traversed the external table and flattened itself in the diploë, in such a manner that it could not be extracted without injuring the internal table. Desport saw other cases in which the perforation of the external table was accompanied by fracture, complete or incomplete, of the internal table; and Percy succeeded in producing these strange lesions in his experiments on the dead subject, Sometimes the ball traverses the anterior wall of the frontal sinus, and lodges in the cavity, without wounding the posterior wall; Schmucker and Collignon, according to Percy, saw cases of this kind. Larrey, at the siege of Saint Jean d'Acre, twice saw a ball fracture the external wall of the sinus and then split in two, one fragment glancing over the forehead and the other lodging in the sinus. But Ravaton has reported an instance which deserves to be noticed more in detail: A grenadier had received a gunshot-wound between the eyebrows, and as the ball had not made its exit, the surgeon had at once judged the injury to be very severe. However, the probe, introduced into the sinus, not passing beyond it, he set to work searching for the ball, and finally, though not without difficulty, found it flattened and as it were incrusted in the floor of the sinus; he extracted it, along with several splinters, without needing to make any incision in the skin; suppuration brought out afterwards other small splinters; but at the end of three months the patient, otherwise well, still had at this point a fistula discharging a slight whitish serosity.

Incomplete perforations of the other bones of the trunk, and especially of spongy bones, like the vertebræ, present nearly the same varieties as those of the cranial bones, either a mere incrustation of the ball at the surface, or a penetration of the projectile to a greater or less depth. The same is true also of the spongy portions

* See for all the cases cited in this article, Ravaton, *La Chirurgie d'Armée;* Percy, *Manuel du Chirurgien d'Armée;* Larrey, *Clinique Chirurgicale,* especially tome v; Jobert, *Plaies d'Armes à feu;* Dupuytren, *Traité des Blessures par Armes de Guerre, etc.*

of the bones of the extremities, which, affording greater chances to art, claim more particularly the surgeon's attention.

Lesions of this kind have been seen in nearly all the bones of the extremities, even in those which, from their small volume, would seem likely to escape. Thus M. Jobert mentions two patients, each struck about the middle of the clavicle, by a ball which lodged in the substance of the bone; doubtless these two cases could only rank among the incrustations. But as regards true perforations, the head and neck of the femur have offered numerous examples; nearly all those who have described gunshot-wounds have had occasion to see them; and I have had represented (*Fig.* 3) a specimen of this kind taken from the Museum at Val-de-Grâce. M. Jobert has seen perforation of the olecranon and of the patella; Larrey, of the cervix femoris; cases of it in the condyles of the femur, and in the head of the tibia, are quite numerous; Dupuytren mentions one of the calcaneum; and the perforations of the carpus and tarsus, *en masse*, are innumerable. Commonly the ball lodges in the bone, and the perforation is incomplete; more rarely the bone is traversed through and through.

The mechanism of incomplete perforations has been studied by Dupuytren, by firing at subjects cased in plaster. If the ball strikes the surface perpendicularly, it penetrates to a variable depth, forming an excavation, or sort of conical channel, of which the external opening, the narrowest part, is of the same dimensions as the ball. The ball is then free and movable at the bottom of this excavation, while the narrowness of the orifice fully explains the dfficulty often met with in its extraction. Complete perforations have been imitated by firing at boards, either single or placed upon one another; when a ball passes through, the orifice of entry is always less than that of exit, contrary to what happens when it goes through the soft parts.

If we examine the course of a ball shortly after the receipt of the injury, we perceive in all cases, according to Jobert, rough bits of bone, sometimes entirely separate and sometimes adherent, sometimes small and like mere rugosities, sometimes at once broad and long; at the level of the orifice of exit, they are more numerous, more closely packed, and more freely bathed in blood. These are the *débris* of the bone, broken off by the ball and pushed before it.

These perforations are generally serious. The surrounding soft parts swell and inflame; the bone itself shares in this action; the limb becomes œdematous above and below; a copious, fetid, reddish suppuration flows from the opening or openings in the bone; a probe introduced into the substance of the bone shows it to be softened and easily penetrated. By degrees the splinters are detached and floated out in the pus; but this does not remedy the evil; caries is developed, extending in different directions, sometimes involving the

neighboring bones, and often giving rise to fistulæ and interminable suppuration, against which amputation is the last and only resource.

At other times nature is stronger, and after throwing out the splinters, sets to work to fill the empty space in the bone, and to heal the wound by a good firm cicatrix. Some patients purchase this result more dearly, at the expense of numerous abscesses successively forming for the extrusion of forgotten splinters. There are, lastly, those in whom the healing occurs as easily as after the simplest wound; neither necrosis nor separation of splinters takes place, but healthy suppuration soon gives rise to granulations, filling up the loss of substance in the bone. M. Jobert has seen such recoveries in perforations of the carpus and tarsus, and even of the bones around the knee-joint. M. Paillard witnessed, at Antwerp, a result quite as successful in a patient who had received a ball in the substance of the external condyle of the femur.

The extraction of the ball is, doubtless, an important step toward such an event; but it is not an indispensable condition. In the patient whose humerus I have had drawn, (*Fig.* 3,) the ball was lodged in the head of the bone, where it had hollowed out a space three or four times its own size; probably it was inclosed in a fibrous cyst; certainly, however, the humerus displayed no trace of morbid change either in the cavity in its head, or at any other point. In another specimen, (*Fig.* 16,) numerous grains of shot were found inclosed in the callus of a fractured jaw, firmly imbedded in the osseous tissue. Larrey has given the history of an officer of the army in Egypt, who received, at the siege of Alexandria, a ball in the substance of the cervix femoris; the wound cicatrized; twenty years after, the patient dying of an affection of the chest, the ball was found in the osseous tissue, where it had so long quietly remained.

Strange as it may seem, these lesions have been met with even in the diaphyses, but less frequently, the compact tissue being more easily broken into splinters than perforated in this manner. Sometimes the ball, flattened and changed in shape by striking the bone, imbeds itself in its tissue without penetrating to the medullary canal; but this seems to be very rare. I have, however, many times seen in the Museum at Val-de-Grâce, a humerus, struck at the middle by a ball which remained incrusted close to the surface; unluckily, this interesting specimen has been lost. In the tibia, (No. 221,) in the Musée Dupuytren, already mentioned in connection with fissures, is seen also the impression made by the ball which was arrested in it.* Oftener the ball traverses the wall of the medullary canal, in which it lodges, as we have said one did in the frontal sinus, sometimes

* I presume this specimen belongs to Obs. 30 of the *Traité des Blessures par Armes de Guerre* of Dupuytren, tome i, p. 316.

maintaining its form and size, sometimes flattening itself against that wall which is yet intact, so that its orifice of entry becomes too narrow for its exit. Percy states that he obtained incomplete perforations of the diaphyses by eight out of two thousand shots fired at dead bodies; the bones thus penetrated were the femur, tibia, and humerus. In clinical experience, it is almost always the tibia that is involved, rarely the humerus; I have not seen a single instance in the femur. Lastly, the rarest case of all is that of complete perforation of a diaphysis. Percy mentions, indeed, Schligting's case, where a ball went through and through the femur, without splintering it at all; but he forgets the important point, namely, how high up the ball struck. I have succeeded in finding but two well-authenticated instances. The first belongs to Dupuytren; a young conscript of 1814, had a ball pass through his leg; he soon after died, at the Hôtel-Dieu. At the autopsy, the tibia was found completely perforated at the junction of the upper and middle third, the two orifices showing no trace of any fracture. The second case, still more curious, and likewise recorded in Dupuytren's work, was that of one of the men wounded in July, [during the Revolution of 1830,] who was struck in the right forearm by a ball, which went through the ulna at the junction of its upper and middle third; he recovered, but only after a long time, and after several splinters had come away.

The theory of these perforations is far from being established on a firm basis. Even in the spongy tissue, how shall we explain the irregularity of the results; there being sometimes mere incrustation and change of shape of the ball, sometimes perforation, complete or incomplete, and most commonly splintered fracture? And the difficulty is greater still for the compact tissue of the diaphyses. I shall not go over the hypotheses which have been brought forward on this subject; what concerns our purpose is the reality of the facts.

One would suppose that the presence of a ball within the medullary canal would induce much graver symptoms than in the spongy tissue. Doubtless either injury is dangerous, but one not much more so than the other. Larrey has seen patients carry balls for many years in the medullary canal of the tibia; to be sure, they had obstinate fistulous ulcers, and at last amputation became necessary; but Bilguer states that he cured a soldier who had a ball in the medullary canal of the humerus, to the extraction of which this willful patient would not consent; and Percy says he knew an old carabineer who carried one twenty-five years in the middle of the tibia; it was found at the autopsy in the centre of an exostosis, of which it had been the nucleus.

We should note these fortunate cases, as evidences of the power of nature; but they hardly serve to modify the gravity of our prog-

nosis when we have not succeeded in extracting the ball; and hence the essential indication in cases of this kind, viz., the removal of the foreign body.

This indication, then, stands first; but M. Jobert has proposed an exception to it, of which I approve. Suppose a ball lodged in the substance of the clavicle, should we persist in removing it, at the risk of breaking the bone? It seems to me that between the danger of letting the ball remain, and that of completing the fracture, there is room for doubt which is most serious, and that the decision should depend on the importance of the bone and the position of the ball.

Extraction being decided on, it should be accomplished by the usual well-known means. Sometimes the orifice of entry is too small to allow of the free exit of the projectile; in a case of this kind Desport used a trephine, to remove a ball from the tibia. When the perforation is complete, it is still useful to examine whether there has not lodged in the track of the ball some foreign body, such as a bit of clothing, as occurred to Dupuytren's conscript. The wound being well cleared, the treatment should be the same as that of complete fractures of the same kind; and every one must see how much the solidity of a bone thus preserved will add to the chances of success.

§ II.—*Of Complete, Simple Fractures.*

I shall arrange under this head likewise four important varieties, viz., (1) transverse fractures; (2) serrated; (3) oblique; (4) separations of epiphyses.

(1.) *Of Transverse Fractures.*—Fractures of this kind have been recognised from the earliest antiquity; they hold a place in all treatises on surgery. Boyer says, indeed, speaking of the tibia, that fracture of this bone is almost always transverse; it may, therefore, seem strange enough for the reality of transverse fractures to be called in question, or denied.

There is, however, in the classical authors, a confusion which must be first explained. They use as synonymous the terms "transverse fracture" and "fracture *en rave*," which differ from one another in several respects. For a fracture to be *en rave*, it needs only that the fractured surface should be even, and should involve the opposite faces of the bone at the same level. [That is, at the surface, the line of fracture should be transverse, however irregularly the bone may be separated within. The applicability of the term *en rave*, *radish-like*, will be appreciated by any one who remembers the manner in which a radish snaps off when bent.] Thus the fracture of the acromion, represented in *Fig.* 25, appears to have been properly *en rave*, although it could hardly be called transverse. The perpendicular fracture of the lower jaw, said to have been observed, would also be *en rave;* and likewise the vertical fracture of the patella,

or certain other fractures with even surfaces, passing obliquely into the articulations. The spongy portions of the bones may offer fractures *en rave* in different directions; and the fracture of the lower end of the radius may even be very nearly both *en rave* and transverse, although with some superficial serration. (See *Fig.* 56.) But the main question is concerning the diaphyses; and I may say at once that I have never seen, either in museums or in clinical experience, and that I have never been able to produce in my experiments, a single case of transverse fracture of a diaphysis.

I would not, nevertheless, omit to state that M. Denonvilliers, in his description of the fractures in the Musée Dupuytren, notes four or five as transverse, chiefly among those of the lower third of the femur. I have, consequently, felt obliged to examine those specimens with the greatest care; and I have assured myself that of them all, the one least open to suspicion, (fracture of the femur, No. 135,) in spite of the callus masking its primitive character, bears features irreconcilable with the idea of a transverse fracture.

After examination of the three great museums of Paris, after repeated experiments on dead subjects of all ages, even upon the fœtus before term, I had firmly denied the existence of transverse fractures in the diaphyses, and believed myself to be alone in this opinion, when I discovered a vigorous champion who had before sustained it, and who, though depriving me of the priority, gave me in return the support of his judgment. Camper had visited the museums of Germany, England, and Holland, and had arrived at the conclusion that neither transverse fracture nor fracture *en rave* had ever been observed except in the patella, and that the long bones were always broken either obliquely or longitudinally.* Cases which Camper had not seen have authorized me to extend greatly the range of fractures *en rave;* and my experiments on the dead body, added to autopsies of recent fractures, also lead me to oppose his assertion touching the direction of other fractures. In the museums he had seen hardly any but old fractures, quite consolidated; which would indeed justly testify against the transverse direction, but would not show so well their real primitive course. A very large class of fractures, omitted by Camper and by all modern surgeons, is composed of such as are serrated.

(2.) *Serrated Fractures.*—I mentioned first in 1838, in my *Mémoire sur les Fractures des Côtes*, these serrated fractures, which I have also observed in the clavicle and humerus; and I was not a little surprised afterwards to find them spoken of under the same name by A. Paré, thus in advance of his own time. My researches now enable me to give a far more complete account of them.

In trying to break the bones of a corpse by a direct blow, in place

* Camper, *Obs. circâ Callum*, op. cit.

of the transverse fractures I sought to produce, I only obtained, in the immense majority of cases, toothed fractures; that is to say, fractures with surfaces set with irregular, angular, pointed projections, so dove-tailed as most frequently to prevent either displacement or crepitation, the lesion being only recognised by an abnormal flexion at the part involved. If the force of the blow produced an incomplete transverse displacement, I found that this was facilitated by the breaking of some of these projections, forming so many little splinters; but there remained enough of them to hold the two fragments together. Still, owing to the abnormal impaction of the angles of the fragments, it was almost equally difficult either to complete or to reduce the displacement, even in the dead body. When the displacement was complete, reduction was still more troublesome, from the difficulty of fitting each projection exactly into its corresponding angle.

These phenomena were so singular that I could not but seek to verify them in fractures occurring during life. I examined, therefore, with more care than ever, the symptoms and anatomical conditions of recent fractures, and was not long in establishing their conformity with the results of my experiments. I believe, then, that I can lay down the general law that the majority of simple fractures from direct blows are serrated, varying in the living as in the dead; that is, showing complete or incomplete displacement, or none at all; but in the two former cases, presenting a difficulty of reduction much increased by muscular resistance. I shall mention again, hereafter, that oblique fractures themselves are very often serrated, and that certain comminuted fractures are nothing more than serrated fractures, in which a large projection has been broken off by the same force, thus becoming a separate fragment.

Does indirect violence also give rise to fractures of this kind? On this point experiment is almost silent, indirect fractures being by no means easy of production in the dead body; but, according to what I have seen during life and at autopsies, it appears that such violence far more frequently gives rise to oblique fractures; and thus that each order of causes has its own proper results, to which it is, so to speak, privileged.

I have observed these fractures in the clavicle and in the humerus, in the radius, alone or together with the ulna; in the femur and in the tibia, and moreover at all ages. When I took, for example, the wards of M. J. Cloquet, in 1842, they contained but two fractures, both of which were from direct violence: the one was in a young boy, the other in a man; the former involved the humerus, the latter the radius; both, presenting neither displacement nor crepitus, had been recognised only by the preternatural mobility; these were striking examples of serrated fractures in the very simplest form.

Serrated fractures with partial displacement are especially easy of

diagnosis, during life, in the ulna and in the tibia. It is by no means rare, in practising surgery, to meet with fractures of the tibia with a slight prominence of one of the fragments, not tending to increase at all, but resisting all attempts at reduction; of this I could cite numerous instances. It is evident that in the femur, and wherever else the fracture is buried within a mass of muscle, these slight displacements are less easily perceived. I have had represented a very beautiful example of this, from the Musée des Hôpitaux. (See *Figs.* 75 and 76.)

As for complete displacements which cannot be reduced, it has become customary to attribute them to oblique or comminuted fractures. I should say that they are very often the result of serrated fractures. There may be seen, in *Fig.* 6, a very beautiful fracture of the femur, produced by a fall from a height, in an old man, who died some days after from concussion of the brain; there was complete displacement with overlapping, which all my efforts were unable to reduce. At the autopsy, I found the fragments shaped as represented, excepting two small splinters, which were found buried in the muscular substance.

Serrated fractures being so common,—the most common, indeed, of all,—it remains to be explained how they have hitherto escaped the notice of observers. Experiments and autopsies conducted with too little care, and, to speak freely, with too blind a faith in the dicta of great authorities, have doubtless caused this strange oversight. In the living subject, notwithstanding their characteristic symptoms, we confound them with other varieties; and a word must be said in reference to these errors in the differential diagnosis.

When the fragments remain in apposition, we can only recognise serrated fracture by one of these phenomena: either by the possibility of bending the bone at the seat of fracture, or by the flexion already produced, either by the determining cause or by the weight of the limb. Now these two characters belong also to partial fractures, properly so called; and hence a confusion not always easily avoided. Sanson observed, for example, a fractured clavicle in which there was a considerable angular projection at the middle; the fragments, separated above, had kept their level below; crepitus could not be elicited. From these circumstances he diagnosed a partial fracture. I have twice seen similar cases; and one of the patients dying, I was enabled to prove by dissection the existence of a complete, serrated fracture. Raleigh, again, being called to a child which had sustained a fall, found the arm swollen, the only other sign of fracture being that he could bend it at the middle; hence he considered it an incomplete fracture.* I have three times seen this in the

* Sanson, art. *Fractures*, etc.; Raleigh, *Gazette Médicale*, 1836, p. 282. See also, in the same volume, p. 50, my report of the dissection of a serrated fracture of the clavicle.

living subject. I have quite often caused it in the dead body; and dissection then showed sometimes partial fracture, but much oftener one which was complete and serrated.

As far as I can judge on a question still so new, angular bending, easily corrected, of a bone, belongs essentially to complete fracture; difficulty of reduction indicates that the bone is only partly broken. In cases where the bone maintains its form, bending only under force intentionally applied, if this bending occurs but in one direction, and that to a very limited degree, the fracture is only partial; more extended flexion, taking place in different directions, would denote complete fracture. But, besides that the periosteum may oppose resistance to flexion in some directions, even when the bone is entirely divided, there are cases in which the relations of the bone permit of its bending only in one direction, and to a very slight degree; thus the radius cannot be much bent except when separated from the ulna, nor can the fibula except when separated from the tibia, etc. To sum up, a careful examination will often establish the differential diagnosis; but I cannot say that this may be done in all cases.

When the fragments have sustained partial lateral displacement, the fracture has generally been pronounced *en rave*, it being forgotten that in that case reduction would be easy. Before discussing the differential diagnosis, it would be well to await proof of the existence in the diaphyses of these fractures *en rave;* but meanwhile let me not pass over one circumstance which may lead to error. It is not uncommon, in examining the internal face of a broken tibia, to discover a perfectly regular, transverse solution of continuity, without serrations; and hence, doubtless, Boyer's assertion concerning this bone. But experiment sifts all these things. I have more than once caused a purely transverse line of separation in the internal face of the tibia, so that at first I thought I had obtained an instance of this "unfindable" fracture; but on stripping the other parts from the bone, and separating the fragments, I have always discovered numerous dentations on the other surfaces and in the thickness of the bone. The so-called fracture *en rave* existed only at the surface; and I note this as so much the more remarkable, since I never have been able to observe similar appearances in any other diaphysis, nor even on the other two surfaces of the tibia.

When, lastly, complete transverse displacement induces overlapping, and we are to determine whether the fracture is serrated or oblique, the only resource is to examine the ends of the fragments by means of the fingers. Suffice it to say that we cannot arrive certainly at the differential diagnosis except in fractures of superficial bones, and that in those deeply seated the form can only be revealed by dissection.

(3.) *Of Oblique Fractures.*—Oblique fractures vary much, according to the degree of their obliquity. Strictly speaking, very few

so-called transverse fractures of the patella have not a certain degree of obliquity; and this obliquity is still more marked in fractures of the olecranon. In the long bones, the generic name of *oblique fractures* is usually restricted to such as have an angle not far from 45°. If the obliquity is greater, they become fractures *en bec de flûte*. [By *bec de flûte* is meant the reed or mouth-piece of a clarionet. The application of this comparison to many fractures will be at once evident.] If they approach parallelism to the axis of the bone, they are called *longitudinal* fractures. M. Campaignac has given the case of an old man who died on the twelfth day after sustaining a fracture of the femur. At the autopsy, a fracture was discovered beginning at the middle of the bone, and running up to a point above the lesser trochanter, its extent being about four and one-third inches. I have an analogous specimen, in which the fracture passes up from within outward to a nearly equal extent. But the most remarkable case which can be cited of this kind, is certainly that presented by M. J. Cloquet, in his *Thèse du Concours*. It is the femur of a slater who fell from a roof. The fracture, commencing between the two condyles, runs up inward to the level of the lesser trochanter, its length being about ten inches. These are, however, quite rare cases; and it is perhaps not out of place to mention that they have hardly been met with except in the femur.

[A man was crushed by the caving in of a bank of earth; and among other injuries, he sustained a comminuted fracture of the left femur. An abscess formed in this thigh, of which he died some three weeks after. The autopsy showed a complete fracture about three inches below the trochanters. From the upper part of this there ran two longitudinal fractures, one anterior and the other posterior. The latter ascended to the lesser trochanter; the former ran also upward and inward to the lesser trochanter, and then, changing its direction and becoming a mere fissure, passed upward and outward to the apex of the trochanter major. Here was a genuine longitudinal fracture, with fissure also.]

As to ordinary oblique fractures, they are sometimes produced by direct, but more frequently by indirect, violence; and perhaps they have something peculiar in their aspect, according to the cause producing them. Examine, for example, (*Fig.* 5,) an oblique fracture of the humerus, produced by direct violence on the dead body. It presents, on its two extremities, serrations, which should have been broken off to give it an unmixed obliquity. Contrast with this an indirect fracture of the clavicle, (*Fig.* 17.) This is really a clean, sharp, oblique fracture, undoubtedly to be called a fracture *en bec de flûte*. In the majority of fractures of the leg from falls on the feet, we can feel under the skin this sharp point, *en bec de flûte*—if, indeed, it has not made its way through the integuments; and I would

recall here the three longitudinal fractures of the femur before mentioned, all arising from indirect violence.

(4.) *Separation of the Epiphyses.*—I rank among fractures these lesions, which some modern authors would consider as distinct from them, because they acknowledge the same causes, present the same symptoms, call for the same treatment, and lastly cannot always be exactly distinguished from fractures properly so called.

On the strength of an equivocal word, an attempt has been made to date back the recognition of this lesion to the time of Hippocrates. On the contrary, it may be regarded as certain, that Colombo was the first to point out its possibility in the sixteenth century; and the slight mention made of it by Paré cannot be thought by any means positive. At best, there were on this point only conjectures and doubts, since in 1759, Reichel put forth a long thesis with three pathological specimens, unaccompanied by details of their history; these specimens would seem to have been simply fractures which had occurred in men of very advanced years. We must then come down as far as 1787, to find in a chapter of Bertrandi some separations of epiphyses, established by dissection.

"I had occasion," says he, "to open the body of a child which had died in the uterus from the midwife pulling upon an arm protruding from the vagina, and found the head of the humerus separated from the shaft of the bone; and in another child which was found after its birth to have one leg shorter than the other, I observed the femur luxated, its head still remaining in the cotyloid cavity." It is plain that Bertrandi's terms are not rigidly accurate, nor are his facts much more so. Thus we read, a little farther on: "I have seen in the body of a child, at M. Sue's, in Paris, the head of the humerus united with the neck of the scapula, and the glenoid cavity hollowed out in the end of the humerus, from separation of the epiphyses occurring three years before. The motions were not impaired; but one could not always look for equal success." To affirm integrity of the movements from merely examining the corpse would show some temerity; but with the new articulation described by the author, such an assertion exceeds the limits of probability.

We may presume that these first attempts left some doubt in the minds of surgeons, and that Delpech, in 1816, believed himself correct in denying the possibility of detachment of the epiphyses. More recently, M. Rognetta and M. Guérétin have resumed the subject in two very interesting memoirs; in which, however, we must regret finding some facts misinterpreted, which are irrelevant to the question, and some others omitted which would have shed much light upon it.*

* See Reichel's Thesis, in the *Thesaurus Dissertationum* of Sandifort, vol. i; M. Rognetta's Memoir in the *Gazette Médicale*, 1834; and that of M. Guérétin in *La Presse Médicale*.

The decollation of the epiphyses has been established by dissection: (1) at either extremity of the humerus; (2) at the inferior extremity of the radius; (3) at either extremity of the femur; (4) at either extremity of the tibia. M. Guérétin says also that he has succeeded in separating the olecranon in the bodies of children; and these are all the facts on this subject, at present possessed by science. Instances are indeed cited of decollation of other epiphyses, but only in the living body, and it is more prudent to rely entirely upon dissections. I shall bring up, in connection with particular fractures, the facts concerning decollation of the epiphyses of each bone; but it will be useful to study first the general subject.

These decollations have been observed mainly during the period from birth to fifteen years of age. At birth they are generally caused by inconsiderate traction on the limbs. M. Champion saw, in 1810, separation of the lower extremity of the left tibia, in a child at term, by violent pulling on the foot. Madame Lachapelle gives a similar case, from a like cause: and another in which the traction on the foot separated at once the inferior epiphysis of the femur and the superior epiphysis of the tibia. In these three cases the children were born dead, as well as in the instance cited by Bertrandi of decollation of the humerus. A similar separation was made out by Chapelain Durocher, in a child which survived for fourteen months; the midwife caused it by hooking her finger in the armpit to assist the delivery.* After birth, also, it requires violent traction, or falls, to produce these decollations; there are no examples of such results from direct blows. M. J. Cloquet dissected a separation of the inferior epiphysis of the radius in a child of twelve years, who had fallen from the top of a tree. M. Rognetta gives a similar case, occurring in a subject fifteen years old. M. Coural was obliged to amputate the thigh of a child eleven years old, for a separation of the inferior epiphysis of the femur, caused as follows: the child got its leg into a hole, as far as the condyles of the femur, and the impulse threw the rest of the body forward.† As to traction, M. Champion has given two remarkable examples, also in boys from eleven to thirteen years old. One had his arm caught in the spokes of a wheel, and the other had his forearm entangled in a carding-machine. In the former there resulted separation of the superior, and in the latter, of the inferior epiphysis of the humerus.

An external injury may likewise separate the epiphyses of a yet undelivered fœtus; but such cases are very rare, for I know of no other example than that of Carus, before mentioned (p. 39.) There

* Champion, *Journal Complémentaire*, tome i, p. 317; Mme. Lachapelle, *Pratique des Accouch.*, tome ii, p. 225, and tome iii, p. 180; Chapelain Durocher, *Thèse Inaugurale*, 8vo, Paris, 8 Frimaire, an xii.

† J. Cloquet, art. *Fractures*, Dict. en 30 volumes; Rognetta, *op. cit.;* Coural, *Archiv. de Médecine*, tome xi, p. 267.

remains one more question: namely, whether such separations can take place above fifteen years of age; and if so, up to what period of life? There have been examined subjects twenty-five years old, in whom the epiphyses were as yet unconsolidated; hence their separation would be possible at this age, although we know of no instances of its occurrence above that of fifteen. Against this view, M. Devilliers has published the very extraordinary case of a separation of the superior epiphysis of the femur in a man fifty-eight years old; but I apprehend some mistake in this case. An old soldier was picked up drunk in the fosse of the Bastile. He had pain from the right hip down to the foot; no apparent contusion, and no shortening, but indistinct crepitation during abduction. After remaining more than a month in the hospital, the patient, walking about and free from suffering, requested his discharge, when he was attacked by an adynamic fever, which carried him off in a few days. At the autopsy, the head of the bone was found separated from the cervix, and the two irregular surfaces presenting prominences and depressions exactly fitting one another. Both were incrusted with a whitish substance like inter-articular cartilage, but extremely thin, and at some points deficient. The head of the left femur was completely ossified with the neck.* All these particulars apply perfectly to an intra-capsular fracture without displacement and without any union; and this explanation seems much more probable than the other.

It may be observed that all these autopsies were made upon male subjects; I may add, also, that among the cases of it observed during life, in which the diagnosis seems best established, there is not one female. I content myself with stating this circumstance, leaving its explanation to others.

The symptoms of decollation of the epiphyses do not differ from those of simple fracture in the vicinity of joints. If there is no displacement, we can only suspect its existence; if there is displacement, according to the extent of this do we easily recognise the fracture, or confound it with luxation. But this is a general question of diagnosis, to be treated of hereafter.

Supposing, then, the solution of continuity to be clearly made out, is it possible to determine whether it is a fracture or a separation of the epiphysis? I believe not. Doubtless, when the accident occurs before the age of fifteen, when the solution of continuity is on a level and in the same direction with the epiphyseal cartilage, the presumption is in favor of the decollation, but certainty can only be arrived at by an autopsy. It has been thought that absence of crepitus was characteristic of decollation; but in many fractures near joints crepitus is wanting; as, for instance, it often is in those of the lower extremity of the radius. Let us see, also, to what conclusion

* *Journal Complémentaire*, tome ii, p. 362.

M. Guérétin has been led by his experiments, made with the express object of separating the epiphyses. At the age of nine months, this was obtained in one out of four attempts; the other three causing true fractures. From two to seven years, decollation occurred once in nine times; the rest being either fractures or luxations. From seven to fourteen, of ten attempts not one succeeded; fracture or luxation being always caused. To this it must be added that, beyond the age of two years, decollation is rarely perfect; there being nearly always a fragment, greater or smaller, detached by actual fracture from the diaphysis, and remaining adherent to the epiphysis. This last result is confirmed by autopsies. In the boy thirteen years old, with separation of the lower epiphysis of the humerus, M. Champion noticed that the outer and posterior part of the epiphysis had carried with it a small bit of the diaphysis, the size of the nail, half an inch in width, and one-quarter of an inch in thickness. In another separation of the upper epiphysis of the humerus, preserved in the Musée Dupuytren, I likewise ascertained that the epiphysis had carried with it a small splinter of the external face of the diaphysis. I have had this specimen represented. (See *Fig.* 4.) The diaphysis is displaced inward, overlapping by several millimètres the level of the epiphysis. Externally are seen the long flaps of periosteum, torn from the neck of the bone, and still attached to the epiphysis. In one point the periosteum is raised up by a part of the bone which could not be shown in the drawing, but which is easily recognised in the specimen, and which forms the splinter alluded to.

In the other autopsies known to us, there is no mention of similar splinters. Does this imply that the separation was simple, and without fracture? We may so much the more reasonably doubt it, since in this second specimen M. Champion himself did not see this splinter, which escaped likewise the examination of M. Denonvilliers. Besides these little concomitant fractures, slight as the displacement was, the periosteum was stripped from the diaphysis to a great extent. *Fig.* 4 gives a very good idea of what may occur in this way.

How are these decollations reunited? From observations made on the living subject, the reparative process goes on as well and as quietly in them as in simple fractures. I have had to treat separation of the lower extremities of both radii in a child six years old; consolidation ensued in the usual time and without deformity. I have also seen a separation of the head of the humerus, sustained at an early age, and united with great displacement; the arm had lost its strength, hanging atrophied and nearly paralysed beside the body; but the union, though unsatisfactory, was very solid. In our drawing, to be sure, no attempt at union is seen; but the child died on the seventh day, in consequence of the very severe local and general disorder.

Consequently, aside from complications, the prognosis is the same as for ordinary fractures near joints. The treatment is likewise the same, and need not be detailed here.

§ III.—*Of Comminuted Fractures.*

Under this general head are included four principal varieties: (1) fractures with splinters; (2) fractures of one bone in several places, that is, with several fragments; (3) fractures by crushing; and (4) fractures involving several bones at once.

(1.) *Of Fractures with Splinters.*—By *splinters* are meant small fragments separated from the bone, comprising but a portion of its breadth or thickness, and which could be taken away without much hindering its consolidation or the recovery of its functions. The name *fragments* is reserved to the more important portions, involving the whole breadth or thickness of the bone, and the removal of which would be notably injurious. The vagueness of some of the terms of these definitions arises from the nature of the things concerned. There are cases in which it would be hard to distinguish a fragment from a splinter, and *vice versâ*.

Fractures with splinters occur chiefly in the flat and in the long bones; the thick bones are rather liable to the crushing, to be mentioned presently. Splinters in the flat bones may comprise their entire thickness without thereby becoming fragments. Such is the case with the small splinter in the centre of the fossa infra-spinata of the broken scapula shown in *Figs.* 22 and 23. But our attention at present is claimed especially by splinters of the diaphyses.

These splinters vary much as to number, size, and form, as well as in the mechanism of their production. When there are not more than one or two of them, they assume generally the shape of a wedge, whose base is toward the surface of the bone. I have been able to study pretty thoroughly their origin in fractures from direct violence: it is then always by the breaking off of a serration, the external violence being severe enough to displace the fragments. The serrated fracture shown in *Fig.* 6 presents small splinters of this kind; but *Fig.* 5 will give a better idea of the mechanism. Supposing the fragments in apposition, and an external force tending to carry the upper fragment to the right, the little projection on the right of the lower fragment will be detached and form a splinter. On the other hand, if the upper fragment is thrown to the left, the *bec de flûte*, presented by it on the right side, will be broken off; thus constituting a splinter of much greater size. This supposition is verified in *Fig.* 7, where may be seen a fracture of the right tibia, with a large wedge-shaped splinter at the outer side of the bone; here the fracture was by direct violence, from the fall of a cask; very probably the first blow broke the bone obliquely, as in *Fig.* 5; but

the pressure continuing, the *bec de flûte* was itself obliquely detached, and changed into a wedge-shaped splinter.

I am inclined to believe that in many cases oblique fractures by indirect violence are complicated with wedge-shaped splinters by an analogous mechanism, so common is this form of splinter in our museums. I have besides seen some examples of it in autopsies. Thus, in the oblique fracture of the clavicle shown in *Fig.* 17, the upper fragment has lost its point precisely in the manner mentioned.

When the splinters are in greater number, they are most frequently the product of a direct cause acting with extreme violence, and by a sort of crushing. Sometimes a beam, or a large wagon-wheel, begins by breaking the bone into three fragments, and exhausts its force in crushing the middle portion. A spent cannon-ball, striking the shaft of a bone, mashes it into a thousand little pieces, without apparently injuring the skin; this is what especially receives the name of *comminuted* fracture. A ball in full motion, striking a long bone, breaks it, splitting and cracking it in all directions, as if it were glass; this is fracture *en éclats*, [like our common phrase "breaking a thing into shivers,"] and gives rise to the most curious splinters. I have had represented (*Fig.* 8) some splinters of a tibia fractured by gunshot, in 1815, which remained buried in the muscles for eight years, and were only discharged in 1823; notwithstanding the absorption exercised on their surface during this long space of time, the oddity and diversity of their forms are easily seen.

The history of these splinters is too intimately interwoven with that of fractures generally to be dwelt upon at length here; it will come up again in connection with the subject of Terminations.

(2.) *Of Fractures with several Fragments.*—These are quite rare, and have not hitherto been sufficiently studied. In *Fig.* 7, besides the fracture of the tibia, the fibula is seen to be broken at two different points; the cause was the fall of a cask, pressing on the bones by a broad surface. I have also had represented a double fracture of the humerus (*Figs.* 35 and 36,) and another of the femur (*Fig.* 74;) but I do not know their causes. Sir A. Cooper has figured a double fracture of the humerus, in an old man of seventy-one, who was thrown down, striking the edge of a curb;* with only this information, it is not easy to account for the fracture being double, and the less, since a direct cause for one portion of it seems to be evident.

To sum up, I know of no cases in which double fracture has been caused in a diaphysis by indirect violence, although I would by no means deny the possibility of such a thing. A direct cause acting by double pressure, or perhaps the joint effect of a direct and an in-

* *Guy's Hospital Reports*, Oct., 1839, p. 232.

direct force, seems most frequently to produce fractures of this kind; but, I repeat, the question needs further study.

In large articulating extremities, for instance, there are some double fractures from a single indirect cause; such are fractures of the condyles of the humerus from falls on the olecranon (*Fig.* 41;) and I have seen several cases of comminuted fracture of the condyles of the femur in consequence of falls on the patella.

(3.) *Of Fractures by Crushing.*—I shall merely mention here, without again recurring to the subject, crushing of the cranial bones, or of the bones of the trunk and extremities, caused by falls from a great height, by the pressure of powerful machinery, or by the action of irresistible violence, as the caving in of a quarry, the explosion of a blast, etc. Here not only the bones are crushed, but also the integuments, muscles and viscera; life is extinguished almost instantly, either in the whole organism or in the limb; and in the least desperate cases we have no longer to treat fractures, but to perform amputation.

But I would speak now of a form of fracture, more common than is generally supposed, and to which suitable attention has not hitherto been paid. It occurs only in the thick bones, and in the cancellous extremities of the long bones; but numerous examples of it can be cited. It has been observed in the vertebræ; and I have had drawn some very remarkable instances of it in the cervix humeri, in the cervix femoris, in the inferior extremity of the tibia, in the calcaneum, and, as I shall have occasion to mention, in yet other regions. The essential character of crushing is the reduction of the bone into a number of fragments crowded upon one another, with condensation, and as it were disappearance, of the intermediate spongy tissue; so that at first the bone seems to have sustained a loss of substance, without the formation of either splinters or *débris.* The appearance of a bone thus crushed is perfectly displayed in *Figs.* 26 and 27, in the neck of the humerus, and in *Fig.* 98 in an os calcis. The closer study of the mode of condensation of the fragments will be aided by *Figs.* 99 and 100, representing a horizontal section of the calcaneum and lower articulating surface of the tibia, disjointed by penetration of the *débris* of the spongy tissue; and, lastly, in *Fig.* 68, I have placed nearly in their natural position the fragments produced by crushing of the cervix femoris; it is plain that even the outer shell of the bone has sustained at several points a loss of substance, the *débris* of which I could not find; through this void the eye penetrates (as well as could be shown in a drawing,) to the interior of this osseous shell, which is quite empty; and of the abundant cancellous substance which should have filled it up, as is seen in *Figs.* 70 and 71, there remain only one or two small shapeless bits.

These ideas may suffice to distinguish what we call crushing, from

comminuted fracture, when the bone at the broken part no longer preserves any consistence, being found in the form of *débris* or splinters lying loosely in the midst of the muscular substance. To make the difference more evident, compare the two humeri, or the calcaneum, before mentioned, with the comminuted fracture of the elbow represented in *Fig.* 45. Here, by the effect of time and gradual absorption, the greater part of the splinters have disappeared; but their vestiges remain in the shape of the little rounded osseous masses, loosely held in place between the bones by bands of fibrous tissue. Examine the lower end of the humerus; look for the head of the radius, for the coronoid process of the ulna; all is mashed, reduced to small splinters, irrecoverably gone. Thus, then, they differ in appearance, in symptoms, and in consequences. Add to this that in crushing there is not, properly speaking, any displacement, the fragments remaining adherent to one another, while in comminuted fracture, on the contrary, there is no cohesion of the splinters, and displacement is inevitable; and we see a vast difference in their diagnosis, prognosis, and treatment.

The causes alone are similar, at least in part, and it is difficult to say whence arises the variety of result. In both cases it is usually a direct shock; a fall on the end of the shoulder, on the elbow, trochanter major or calcaneum; but sometimes the crushing may also result from indirect violence, as for instance in the vertebræ, radius, or tibia; which can never be true of comminuted fracture.

[In the United States there is not generally so great a distinction recognised between comminuted fracture and crushing, the difference being considered one of degree only.]

There is another fracture, which in the living subject so much resembles crushing that it would be difficult to distinguish them; I allude to simple fracture of the articular extremities, with more or less marked impaction of one of the fragments in the spongy tissue of the other. I shall recur to this point in speaking of displacement by penetration. The difference is very important in regard to consequences and to treatment; for mere displacement by penetration may be reduced, and all deformity obviated, while it is very doubtful if such reduction can be effected and maintained in cases of actual crushing. We shall have especially to recur to this subject in treating of fractures of the lower end of the radius, and of the cervix femoris.

(4.) *Of Fractures involving several bones at once.*—This subject has hardly attracted the attention of any observers. It is, indeed, mentioned in treating of fractures of both bones of the forearm or of both bones of the leg; but without any distinction from simple fractures, and the only question raised regarding them has been whether they should be called *complete* [complicated?] or *compound.* There is surely something more here to be studied; and first, to fractures

of the forearm and of the leg should be added those involving several ribs, constituting a group, viz., of such fractures as involve several parallel bones; secondly, another group includes cases where fractures are distributed among several bones more or less removed from one another.

The first point of inquiry is, in what proportion do these fractures occur, compared with others; and in regard to the first group, it is nearly impossible to determine this from our present knowledge. In no statistics has the attempt been made to divide cases in which one rib was broken from those involving several; and too often surgeons confound, under the vague title of fractures of the forearm or leg, such as are strictly limited to one of the bones. I have, indeed, in my general tables (see page 23,) placed separately fractures, for instance, of the tibia from fractures of the leg; but these figures are evidently relative and unreliable, and I find them no more certain in other similar tables.

As for multiple fractures of the second group, I have already said that there were thirty cases in a total of 2358 patients; to repeat, they are as follows:—

Fractures of both legs	9
" " the thigh and leg	3
" " " thigh " arm	3
" " " thigh " forearm	2
" " " thigh " clavicle	1
" " " arm " skull	3
" " " skull, thigh and leg	1
" " " skull, thigh " arm	1
" " " skull, thigh " forearm	1
" " " skull, thigh, leg and pelvis	1
" " " vertebræ and leg	1
" " " vertebræ " both legs	1
" " " vertebræ, thigh and ulna	1
" " both clavicles	1
" " one clavicle and the ribs	1

I have sought in this enumeration to observe some order, following especially the degrees of frequency; and we find that these thirty patients sustained in all sixty-seven fractures; one alone had four; six had three, and the rest had each at least two. I say at least, since fractures of the leg, of the forearm, and of the ribs are each counted here as single fractures. The most frequent were:—

Of the leg	26
" " thigh	14
" " arm	7
" " skull	7
" " clavicle	4
" " forearm	3
" " spine	3

From this simple statement it may be concluded that falls are the most frequent causes of these multiple fractures; there are hardly any but those of both legs, of the clavicle, and of the ribs, which can be attributed to direct violence; and it is curious enough to note this difference between multiple fractures of single bones, which appear generally to depend on causes of this sort, and those of several bones, which show an etiology just the opposite.

One would suppose that in all cases the danger to the patients would increase with the number of fractures; but when the cause is a fall from some great height, to this first danger is added another, arising from visceral injury, or from general shock. The prognosis is then very serious, few patients recovering under such circumstances. If, however, the symptoms of shock pass off, there occurs a very remarkable phenomenon pointed out by Dupuytren; it is one of his ideas which I have happily saved from oblivion. He says that the danger of wounds and of fractures, although doubtless increased by an increase in their number, is still not in direct ratio with that number. At first sight, one would presume that several fractures complicating one another would mutually react unfavorably, each one thus giving rise to graver symptoms than if it had occurred alone. Now, the contrary is true; when there are several fractures, each one induces slighter symptoms than if it were by itself; and Dupuytren, after at first viewing this fact with astonishment, became assured of it, and looked for it subsequently as natural, and to be expected. I repeat that the danger is always greater for the patient, but less for each particular fracture; inflammation is less to be feared, and consolidation more readily occurs. Cannot this be explained by the supposition that the vital force is then distributed, so as not to excite around each fracture the amount of reaction which would take place around it if solitary?*

I have followed out this idea, which would perhaps find a more appropriate place under the head of Prognosis, to show that the special study of multiple fractures is possessed of real interest, and that it has already been of advantage. As to fractures of parallel bones in particular, we have to fear a blending of the callus, almost without inconvenience in the leg, but too frequently troublesome in the forearm; of this, as occurring in the ribs, I have given a fine example in *Fig.* 9. We shall recur to this in examining Special Fractures.

§ IV.—*Of Complicated Fractures.*

Fractures consisting essentially and exclusively in a division of the bone, it follows that any accompanying lesion, either in the surrounding

* *Gazette Médicale*, 1832, p. 394.

parts or in the economy at large, should be properly considered a complication. Thus, among the local complications would rank the bruising or tearing of the periosteum, of the muscles, of the aponeuroses, of the vessels, nerves and skin; injuries to the joints, either by communication with the fracture or by luxation; and lastly, visceral mischief, whether caused by the original violence or by the fragments themselves. Thus also we should rank as general complications, traumatic fever, all coincident internal inflammations, and lastly cachexies or diatheses. But bruisings and even lacerations of the periosteum and of the muscles are so frequent in cases of fracture, that it has become customary to look on them as associate phenomena rather than as complications; and so also of traumatic fever; moreover, internal inflammations have been regarded as simply coincident, although their influence upon consolidation exceeds even that of diatheses and cachexies; so that the number of complications is greatly lessened. Even the passing of a fracture into a joint has been excluded here, and called a variety merely of fracture; and lastly the English surgeons have ended by limiting the denomination of *complicated* [compound] fractures to those which communicate by a wound with the external air.

[It is difficult to understand how M. Malgaigne can have fallen into this error, since in English and American works the limitation of the term *compound* is so exact, and the definition of *complicated* fractures so clearly given; the former implying the existence of an external wound communicating directly with the seat of fracture, and the latter that of some other injury materially modifying the case either locally or generally. Thus a fracture of the femur, with luxation of the hip-joint, is said to be complicated; so is a fracture of the leg, with delirium tremens; but the term *compound* would not be applicable to either, unless there should be present the local condition above stated, in which case the injury would be a *compound complicated* fracture.]

This simple statement shows how much that is arbitrary has been advanced upon this subject, and forewarns us of deficiencies which will be met with. In what circumstances, and how, do all these complications supervene? What is their order of frequency? Which sex, and what age, are most liable to them? What fractures do they generally accompany? I am not now speaking of the prognosis or treatment; on these I shall hereafter dwell as much as possible.

As far as I am enabled to state, from what I have seen, injury of the nervous trunks in cases of fracture is excessively rare; that of blood-vessels is a little more common. The complication of fracture with luxation is also quite rare, except in those cases in which a certain fracture is an indispensable condition of a certain luxation, (which do not come within the scope of the present volume.) These

cases excepted, of the 2358 fractures collected at the Hôtel-Dieu, four only were accompanied by luxations, viz.:—

1 fracture of the cervix humeri with luxation of the head of the bone.
1 " " shaft of the humerus with luxation of the head of the bone.
1 " " leg with luxation of the humerus.
1 " " humerus with luxation of the femur.

Next come fractures penetrating into joints, which are much more common; and lastly those attended with wounds of the skin, the most frequent of all complicated fractures. I would say, concerning these last, that we must distinguish three very different cases; (1) where the wound of the skin does not communicate with the fracture, and adds nothing to the gravity of the prognosis; (2) where the wound does so communicate, but is caused by direct violence acting from without inward; (3) where the wound is due to protrusion of one of the fragments, from within outward; this can hardly occur but in indirect fractures, or when patients with direct fractures imprudently attempt to walk or stand on the limb. We shall return to this distinction when on the subject of Prognosis.

As to general complications, some have already been studied under the head of Predispositions; and there will be occasion to refer to them all under that of Terminations.

ARTICLE III.

GENERAL SEMEIOLOGY.

In the preceding article, it was in some sort necessary to discuss the diagnosis of incomplete fractures, as far as their history was traced; what follows will therefore relate almost exclusively to complete fractures, single or multiple, simple or complicated.

The phenomena to which these fractures give rise are numerous and varied. To study them nearly in the order in which they appear, they are: cracking heard by the patient at the time of the accident, pain, loss of power in the limb, contusion of the skin, swelling, immediate or subsequent, preternatural mobility at the seat of injury, deformity from displacement of the fragments, and crepitation.

(1.) *Of the Cracking.*—It is almost impossible for a bone to give way without a noise more or less clear and dry, which would seem sufficient to decide the diagnosis. But the sound of the blow or fall sustained, the surprise, the pain, the fright, the cries of the patient at the time, other noises,—in a word, so many causes hinder the perception of the crack, that it is heard by the patients in only a very small proportion of cases. They are especially apt to hear it when

the fracture occurs, we may say, without external violence, by sudden muscular contraction; or perhaps when the bones, being weakened, are broken in bed by a very slight effort; it sometimes even reaches the ears of the by-standers. It is certainly a valuable sign whenever obtained; but we must not forget that the rupture of tendons, or of ligaments in cases of luxation, may also cause a clear noise, so much the more readily confounded with the crack of a fracture, since neither lasts more than an instant, and the ears hearing them are seldom expert.

(2.) *Pain.*—Pain is a symptom very frequently complained of; I would not say always, for I have seen some cases of fracture, especially in rachitic persons, in which it was absent. There appear to be in this respect three classes; sometimes the pain is slight, or wanting; sometimes it is excessive, extorting violent screams from the patient, and persistent, or even increasing in severity; lastly, in most cases it is quite acute at the moment of injury, but subsequently declines, at least unless it is excited anew by some motion. In the first class, the insignificance of the pain has seemed to me attributable to rachitic softening of the bones, whether in children or in old persons; in the second, its severity is due to a morbid state not thoroughly understood, connected with inflammation of the periosteum or of the medullary tissue. Doubtless the sensibility, in some exaggerated and in others blunted, may have an important influence on the manifestation or even the perception of pain; or violent emotions, as on the field of battle, or disorder of the mind, as in insanity, may prevent the sensation of pain at the time of the injury; the suffering, however, may become very severe a few moments, hours, or days subsequently.

The pain which is felt at first has, however, but slight value in the eyes of the surgeon; while that which is persistent, and especially that which on careful examination can be renewed or increased, may become very important in diagnosis. Often in fractures of one bone of the forearm or of the leg, the sound one serving to support the one injured, and the thickness of the muscles, or the swelling, masking any displacement or mobility, the pain alone gives a clue to the existing lesion, and warrants a diagnosis certainly not positive, but quite probable; or sometimes, calling the surgeon's attention, it puts him in the way of seeing other symptoms corroborative of its testimony. But there is one caution to be observed; the pain may exist at several parts of the limb, especially in indirect fractures; and it is of importance not to confound that caused by the blow and its resulting contusion, with that of the fracture itself. The degree of severity of the pain gives no light on this point; very often the contusion is much more painful than the fracture. But if the finger be passed slowly and carefully over the whole length of the suspected bone, unless it has been subjected directly to external violence, the ab-

sence of all pain on pressure will prove its integrity; on the contrary, the existence of pain more or less severe at a circumscribed spot would afford strong presumption of a fracture. In the opposite case, viz., if the external violence has acted on the bone, causing contusion and even inflammatory swelling, pressure usually induces pain toward the edge of the contusion or swelling; this pain increases as the finger approaches the centre of the spot, but still there is a considerable space over which its intensity is nearly equable. If, however, there be a fracture, the instant the finger rests over it the pain is increased, violent as it may have been in the parts around; repeating the experiment, we may frequently succeed in exactly defining with the nail the seat of this sudden accession of pain, which disappears a few millimètres above and below. More than once, from this sign alone, I have ventured to diagnose a fracture, and to fix as the period necessary to a cure, that required for perfect consolidation. In default of every other subsequent symptom, persistent pains, brought on by any attempt to use the limb, would prove the truth of my prophecy.

It will be seen, nevertheless, that in such cases the diagnosis is open to some doubt, and that its precision will depend much on the tact and experience of the surgeon. It is therefore merely a probable diagnosis, and I freely admit that the chances of its accuracy are only about one in four or six. There still remain also cases in which the localisation of the pain is far less marked, and in which the prudent surgeon will make it a rule to wait, reserving his diagnosis for the time being, or giving none at all.

(3.) *Loss of Power in the Limb.*—This symptom, which has been considered as of great significance in many fractures, is in reality of very little value. It is by no means rare to see patients with fracture of the fibula, walking, or with fracture of the radius or ulna, moving the hand and forearm; moreover I have seen an old man with transverse fracture of the patella get up after his fall and walk, and another do the same with a fracture of the cervix femoris, the signs of which only appeared after he had been several days in bed. It is now well known that a fracture of the clavicle, even with displacement, may not prevent the patient from putting his hand to his head; and I have assured myself that some patients having fracture of the cervix femoris, with shortening, could still flex the thigh and raise the heel from the bed. The interlocking of the serrations, or the impaction of the fragments, may partly account for these phenomena; and when the evident displacement of the fragments excludes this mode of explanation, as in fractures of the clavicle, it has been supposed, with some reason, that these patients are enabled by the absence of pain to do what is impossible for others.

It is certainly true that the majority of fractures induce a notable hindrance, or even an entire incapacity, of motion in the limb; but

this depends on two very different causes, viz., the breaking of the bony levers, and the pain. To assign to each of these its due share in the effect produced, is often very difficult; and, indeed, a simple contusion, without any fracture, may render motion more painful than an actual fracture would. I have several times seen falls on the hip prevent the patient from getting up, walking, or raising the heel; while the absence of every other symptom, and the rapidity of the cure, forbade any suspicion of fracture. The same thing occurs in the shoulder, as well as in other articulations. It is often very embarrassing to decide whether a difficulty of walking arises from a mere sprain, or from a latent fracture of the fibula. We see, then, how carefully we should weigh this symptom in forming a diagnosis.

(4.) *Contusion and Ecchymosis.*—I intentionally put these two phenomena together, although in some respects they are unconnected; contusion being strictly possible without ecchymosis, and ecchymosis often occurring entirely apart from any external contusion. But ordinarily they are so closely associated that there is some advantage in treating of them together.

Contusion, mainly recognisable by the bruising of the skin and abrasion of the epidermis, usually indicates pretty exactly the spot affected by any external violence, or the point of the surface struck in a fall. In direct fractures, it at once calls the surgeon's eye to the seat of fracture, and sometimes, in default of any other source of information, discovers to him the cause. Thus, in a fracture of the patella, or olecranon, a bruise of the skin over the bone would indicate a fall on the knee or elbow. On the other hand, we must observe a prudent distrust of some indications furnished by contusion. It is known that when it occurs on the head the point of injury often becomes the seat of a soft and compressible effusion of blood, while the extravasation into the surrounding tissue offers a resistance nearly as great as that of bone; whence has often arisen the suspicion of a fracture with depression, none such in reality existing. I have made the same observation in regard to most of the superficial bones, — the tibia, patella, olecranon, even the infra-spinous portion of the scapula,—and shall take care to recur to these facts at the proper time and place. It may suffice for the present to point them out to the young surgeon.

But often the integuments present no other trace of contusion than mere ecchymosis; and when the fracture is indirect, ecchymosis may also occur in its neighborhood; hence it is hard to say on what precise point the force has fallen. Dupuytren, in some cases, attached great importance to this inquiry, and perhaps he sometimes displayed in it less than his usual sagacity. For instance, he thought, erroneously, that luxations of the humerus on the scapula were never caused by falls on the point of the shoulder; and, on the other hand,

that falls on the elbow or wrist never fractured the cervix humeri. As a necessary consequence, in cases where the diagnosis lay between these two lesions, he examined with the greatest care whether the elbow or wrist showed any mark of contusion, any ecchymosis, any pain, or even a spot of dirt, indicating that one of these points had struck the ground; and these slight indications would at once incline his mind to the idea of a luxation. Such, indeed, was the strength of his prepossession in this respect, that the patient might in vain declare, distinctly, firmly, and constantly, that he had fallen on the shoulder. Dupuytren evaded this testimony by alleging that the point struck was naturally thought to be that where most pain was felt. This assertion is doubtless true in many cases, and the fact should be carefully considered before the statement of a patient is blindly accepted. On the other hand, we should avoid the opposite extreme of always rejecting such evidence; the degree of intelligence of the patient, the clearness of his story, and the consistency of its details, should be well weighed in coming to a decision.

Moreover, just as the external violence causes sometimes contusion and bruising, sometimes a simple ecchymosis, and at other times leaves no trace at all, so also the ecchymoses from fracture vary in their seat, extent, and mode of appearance, while sometimes they are entirely wanting. Hence the difficulty of drawing any conclusions from them; but their study will be better pursued when we come to each particular fracture. I shall confine myself here to the statement that they are in old people both more considerable and more lasting, often remaining even after consolidation; they then extend themselves chiefly by reason of the mass of the extravasated blood, and we see them gradually invade the tissues more and more widely, spreading especially downward; sometimes blood effused very deeply only reaches the surface after some length of time. Fractures of the cervix humeri particularly have afforded me fine examples of this; and the knowledge of the mode of appearance, of the progress and of the decline of these ecchymoses, constitutes in such cases an essential element in forming a prognosis.

(5.) *Swelling.*—The swelling may be primary or secondary, and is owing to causes which, though very different, should be considered together on account of the similarity of their effects. At the instant of the fracture, there is often, but not always, an effusion of blood around the fragments, and an extravasation into the surrounding tissues, constituting strictly an internal ecchymosis, which, however, seldom betrays itself unless the integuments are laid open. When the fracture communicates with a superficial articulation, as, for instance, in a rupture of the patella, it is not uncommon to find the joint much augmented in volume by a large effusion of blood within the synovial membrane.

A little later, the irritation developed maintains or increases the

swelling, but at the same time modifies its nature. The blood, partly absorbed, is replaced in the tissues by an effusion of plastic lymph; in the articulations this accumulation of lymph constitutes a true hydarthrosis. This finally disappears without producing any further effect; while to the inflammatory engorgement of the tissues usually succeeds a harder and more persistent swelling, which is the external callus.

Primary or secondary, the swelling may quite as well be caused by a contusion as by a fracture; and, so far from being of any use in diagnosis, it on the contrary seems rather to mask more closely what exists beneath it. This is usually the case; and the practitioner should suspend his judgment until the swelling disappears. But it must be said that in some obscure cases the swelling may put us in the way of making a very probable diagnosis. Thus, when a misstep has given rise to a lesion of the ankle, and the surgeon doubts whether it be a fracture of the fibula or a sprain, the existence of swelling above the malleolus would be a strong argument in favor of the former supposition. In some cases in which the knee has been attacked by violent inflammation as the effect of a fall, and the outline of the patella can no longer be traced, the hydarthrosis has afforded me a valuable means of diagnosis. If we produce fluctuation, and perceive it clearly over the centre of the patella, there remains no doubt that the effusion is close beneath the skin, and hence that there is a transverse fracture of the patella, with separation of the fragments. But this is perhaps the only case in which the swelling can serve to completely establish a diagnosis.

(6.) *Preternatural Mobility.*—Here at last we come to a chief symptom, characteristic and nearly pathognomonic of fracture; and I am astonished at the neglect it has sustained in most of our dogmatic treatises. Mobility seems so inevitable a consequence of the complete breaking of a bone, that at first sight nothing would seem so simple as to demonstrate it, or so easy as to interpret it; but here, as in everything, we find out difficulties as we study the subject more deeply.

First, all fractures, even if complete, are not accompanied by a mobility as evident as would be desirable for making out the diagnosis; there are cases in which it can only be recognised by the aid of particular motions; there are some in which it cannot be recognised at all. This is especially true of fractures by crushing, and of the ordinary fractures of thick bones, surrounded by numerous articulations. We cannot directly grasp either of the fragments; to move them we must move the whole *en masse*, and we cannot determine whether the mobility resides in the suspected seat of fracture or in some neighboring joint. This difficulty is presented in the highest degree in fractures of the bodies of the vertebræ, and in those of the carpal and tarsal bones. It is met with also in fractures of long bones

occurring very close to joints, where one of the fragments cannot be seized, either from its small size or from its being buried in the mass of the tissues. Nothing is more difficult, for instance, than to say where the mobility resides in a suspected fracture of the cervix femoris, and in certain fractures of the lower end of the radius. After these come fractures of the diaphyses, involving only one bone of the leg or forearm, the sound bone acting as an inflexible splint for the other. And lastly, as I have already remarked in speaking of serrated fractures, even where there is but one bone in question there are cases in which the mobility is undetected from want of skill in the observer.

As, indeed, the mobility has hitherto been hardly looked upon as more than an essential accessory to crepitation or displacement, its production has only been sought in order to elucidate one or the other of these phenomena. The fragments being left to themselves, the nature and extent of the displacement spoke so plainly, and the mobility also was so evident, that further examination was rendered useless. If, on the contrary, the fragments had remained nearly or quite in apposition, the disturbing of them was not dreamed of except to produce crepitation, by movements to be presently described, the object of which was to rub one fragment on the other; and more than one evident fracture has been misconstrued because displacement was wanting and the nature of the mobility did not permit this rubbing and consequent crepitation.

Now the means of demonstrating the mobility alone vary according to the seat and nature of the fracture. In the shaft of the humerus or of the femur, the upper fragment is to be fixed, and the knee or elbow carried in different directions; the limb is then seen to be bent, the angle being at the seat of fracture. In the clavicle, the mere weight of the shoulder will produce this angle; and if it has disappeared by the patient lying down, it may be reproduced by pushing the shoulder downward and inward. In fractures of the fibula, Dupuytren embraced the tibia with the four fingers of each hand, while with the two thumbs, stretched toward one another but not touching, he made pressure alternately upon two points of the fibula; thus pushing toward the tibia one fragment or the other, and discovering the mobility. A similar manœuvre will answer for fractures of the tibia, or of either bone of the forearm. But when the fracture is close to an articulation other data are necessary; we must know in what motion the fragments best play one upon the other. Thus Desault conceived that in doubtful fractures of the cervix femoris the thigh should be rotated; the arc of a circle, described by the great trochanter, should indicate by its extent whether this apophysis were still supported by the unbroken cervix, or moved merely by itself. M. Maisonneuve has discovered two valuable movements of this kind for testing certain fractures of the lower ends of the radius

and fibula. Thus in the former we may frequently detect a very sensible mobility by strongly bending the hand backward; in the latter we may separate the fragments by carrying the point of the foot outward—results attainable in no other way. I limit myself here to these examples, having to return to this subject in connection with particular fractures.

But in this examination we must not be misled by certain deceptive appearances. I shall say nothing of rachitic bending of the bones, which is so rare an exception, that its very rarity is enough to put the surgeon on his guard. Pelletan has published the history of an osteo-sarcoma of the humerus, at the lower part of which the bone appeared movable and flexible; the autopsy showed that this was owing simply to softening, but circumstances more commonly met with may so much the more easily lead us into error. Dupuytren has warned us not to mistake for preternatural mobility the normal flexibility of the fibula, which is most remarkable at the middle of the bone, where it wants support. This mistake is more difficult to avoid in the ribs, which appear to bend under pressure, whereas they are only pressed inward; and which sometimes, in cases of senile rachitis especially, really bend under the fingers without any fracture. I shall never forget having diagnosed a fracture of the ribs in the axilla, because the bones seemed to me to yield at that point, when, as appeared from the autopsy, the real seat of injury was several centimètres in front of it. We should also avoid mistaking the normal motion of a joint for the mobility of a fracture close to it. Lastly, I cannot too strongly warn young surgeons against an optical illusion not always easy to dispel. Suppose a fracture of the leg or forearm, with the skin deprived of its suppleness, whether as the effect of age or of inflammation; in endeavoring to produce angular deformity, we may find the skin to yield as if following the bending of the bones, and yet in spite of the appearance, the bone may be found to be intact. The deception is less likely to occur in recent fractures, where other symptoms come to the surgeon's assistance; but in fractures arrived at the period of consolidation, when it is to be decided whether or not the callus is sufficiently firm, the want of mobility constitutes our only means of judging; and I acknowledge that more than once this yielding of the skin has left me so much in doubt, that I have kept the limb at rest beyond the time strictly necessary, for fear of a fibrous and insufficient callus.

(7.) *Deformity.*—Whenever the fragments sensibly change their relative position, their displacement is betrayed by the change in the form of the limb; and often an experienced surgeon can at a glance divine the nature of the injury. It would however be unsafe to trust too much to first appearances; the deformity may be due as well to a luxation as to a fracture; moreover, a severe contusion with

effusion of blood produces abnormal elevations which might easily be taken for either, or might, if a fracture were present at the same time, lead to error as to its seat and as to the nature of the displacement.

An old man had fallen down on his side; an immense effusion extended over the hip and outer half of the thigh; the shortening gave evidence of fracture; but at first sight this seemed to occupy the shaft, while in reality it involved the neck, of the bone.

Another had been violently struck on the back of the shoulder by a carriage-wheel, and the depression and deformity of the part were such as to make me suspect a luxation backward of the humerus. The shortening and crepitation indicated a fracture of the cervix; but the deformity, which arose from a very large effusion of blood, so imposed upon the eye, that a careful examination was necessary to convince me that it did not proceed from a dislocation. Such instances could be easily multiplied; we will therefore return to real displacements, and state what are the means of verifying them.

There are six varieties of displacement, some of which may exist alone, though usually several of them are combined. They are (1) transverse, or in the thickness of the bone; (2) angular, or in its direction; (3) rotary, or in its circumference; (4) overlapping; (5) penetration; (6) lastly, direct separation of the fractured surfaces.

Transverse displacement is always due to external violence, throwing one of the fragments forward, backward, or to one side; it shows itself in various degrees, the fragment leaving its position by several millimètres, by one-half or two-thirds of its thickness, or entirely abandoning the opposed end of the other one, when overlapping becomes inevitable, unless there be a parallel bone to prevent it. Overlapping occurs still more when the fracture is oblique; and in any fracture of a diaphysis, some degree of transverse displacement is essential to overlapping, which in its turn involves, with rare exceptions, a certain amount of angular flexion of the bone or of the limb.

This displacement is recognised by the projection of the fragments in opposite directions, or, if the bone can be examined only at one surface, by a greater or less inequality at the level of the fracture. This may be perceptible to the eye, but it is always important to confirm it with the finger; we thus find out whether it is caused by an actual fragment, or merely simulated by splinters pushed out of place. When thus ascertained, it seems as if mistake were impossible; still there are numerous sources of error, as already mentioned. I do not allude to exostoses or to any other tumor of bone, although the surgeon should be always on his guard concerning them. But the normal inequalities of certain bones have been often mistaken for signs of fracture, as at the lower end of the fibula, at the upper end of the femur, at the elbow, etc. I shall again refer, at the proper

time and place, to these anatomical points; but I shall here relate a curious case, setting forth a source of error hitherto unsuspected.

An insane man, having sustained a severe fall, was brought into my wards. The left thigh was the seat of a considerable swelling; but on close examination, I decided that no fracture existed, and treated the patient accordingly. Death ensued from other lesions, at the end of several weeks; the thigh having nearly resumed its natural volume. What was my amazement, on touching this thigh before the autopsy, at finding, three fingers'-breadths above the knee, a marked and firmly resisting prominence, exactly continuous with the anterior face of the bone! I could only explain this phenomenon by the supposition of a fracture, the inferior fragment being displaced backward; but why had I not detected it during life? Dissection cleared up everything; immediately above the capsule an effusion of blood had taken place in the cellular tissue, between the bone and the quadriceps; this effusion, having become dry and hard, was at death projected upward, so that through the integuments nothing distinguished it from the bone; while lower down it was abruptly terminated by the capsule, and hence the prominence which had so puzzled me. Otherwise the femur was completely sound.

According to Boyer, transverse displacement pertained exclusively to transverse fractures, and hence nothing should have been easier than to remedy it. I have given the correct theory of these fractures, and I repeat that, even with a transverse direction, the great majority of fractures present serrations more or less considerable. Hence results the difficulty, sometimes invincible, of remedying a transverse displacement, however slight it may seem, and hence the necessity of strong extension for this purpose. At other times, also, it is kept up, or even augmented, by muscular action; in oblique fractures of the leg, for instance, it is not rare to see the upper fragment of the tibia making an obstinate projection forward, and threatening to pierce the skin. Here the reduction is sometimes very difficult—its maintenance still more so; and we shall see, in the article concerning Treatment, to what formidable means we must resort in such cases.

Angular displacement is frequently caused by external violence, as is especially manifest in cases of incomplete fracture; but another and more permanent cause is the bad position of the trunk or of the limb, the weight of one of the fragments, or, lastly, the restlessness of the patient. Often, in fractures of the femur, the limb being placed in a proper apparatus, the pelvis inclines too much to the sound side, drawing with it the upper fragment, the lower end of which then projects outward. I have seen the same result brought about directly by the patient, in certain cases where the limb was completely enveloped in a bandage up to the groin. The perspiration retained by this induced an itching at the upper and inner part

of the thigh, making the patient scratch himself; to do which he was obliged to pass his fingers between the bandage and the skin, pushing out the fragments, already at an angle with each other. The weight of the limb is especially to be dreaded in fractures of both bones of the leg, in which the heel, being badly supported, gets lower than the rest of the limb, inevitably causing an angular projection forward at the seat of fracture.

Lastly, muscular action sometimes constitutes a cause of angular displacement, when the fragments are held together by their serrations, the contracted muscles tending to approximate their points of attachment. But even when due to this cause, this displacement is usually easy to overcome, unless on account of the depth of the fracture or the small size of one of the fragments.

Rotary displacement, or that in the circumference of the bone, takes place when one fragment executes a movement of rotation, the other remaining stationary; the former being generally the inferior. Sometimes this displacement is owing to external violence, or to motions impressed on the limb after the fracture; sometimes, perhaps, to muscular action; more frequently to the weight of the limb, favored by an improper apparatus. The type of this displacement is manifested in fractures of the neck and of the body of the femur; and in giving an account of these, reference will be made to all the opinions entertained on this subject.

Overlapping is sometimes induced by the same cause as the fracture itself, as when a fall on the feet breaks the femur obliquely, bringing one of the fragments out through the skin; sometimes by the mere weight of the body resting upon a bone already broken. In this manner Paré, when his leg was fractured by the kick of a horse, in stepping back to escape another kick, caused the fragments to overlap and project through the skin. But oftener muscular action is here the essential cause, whether at the time of the injury, or during the course of the treatment; it is at least the most troublesome difficulty to overcome. When this acts alone, it always draws up the lower and less weighty fragment toward the upper, made immovable by the weight of the body. But this has been improperly stated as the general rule; and practitioners should bear in mind that often the body, sliding down in the bed by its own weight and by its inclined position, pushes the upper fragment against the lower. Such is especially the case in fractures of the femur.

Displacement by *penetration* belongs somewhat to overlapping, its essential effect being to shorten the bone; but it differs from it in generally occurring without transverse displacement. It takes place only in indirect fractures of the spongy extremities of the long bones, and is always caused by external violence, at the same time with the fracture itself. Usually, then, it is the diaphysis which buries itself in the cancellous tissue of the epiphyseal portion. Fractures of the

cervix humeri (*Figs.* 29, 30, 31, and 32,) and of the radius (*Fig.* 54,) offer quite frequent examples of this. It seems as if the contrary sometimes occurred in the cervix femoris, where the epiphyseal portion buries itself in the spongy tissue of the other fragment (*Figs.* 69 and 70;) and there are in the Musée Dupuytren several specimens of recent fractures, in which the penetration has actually taken place without crushing of the great trochanter. But these cases are very rare; and after consolidation has occurred it is perhaps impossible, as in the two instances cited, to determine whether there has been crushing or mere impaction. The difference between these two states is far more marked in the cervix humeri; and in strictness, crushing cannot occur without impaction of the fragments; but this kind of displacement may also take place in simple fractures, like most of those of the lower end of the radius.

In the majority of cases the penetration is more considerable on one side than on the other, so that it is almost always accompanied by angular displacement. In fractures of the radius, the angle is generally open posteriorly, salient anteriorly; in fractures of the neck of the humerus and of the femur, the angle of union of the head with the diaphysis diminishes in aperture in proportion as the penetration is greater. Moreover, it must not be thought that the impaction is as marked in the beginning as after the occurrence of consolidation; in examining, for instance, *Fig.* 59, one would suppose that the diaphysis was buried to a depth of more than two centimètres in the spongy tissue of the epiphysis. It is not so; all the triangular production of spongy tissue, joining one portion to the other, is formed of callus; and *Fig.* 57 gives an exact representation of the primitive displacement, before the callus had filled up the angle left between the two fragments. I would add, lastly, that the fragments are not crowded together and adherent to one another, as in true crushing. It is essentially the consolidation which produces the appearance of so marked an impaction.

Finally, displacement by *separation*, long regarded as exclusively belonging to fractures of the patella, olecranon, and os calcis, and, as in those cases, solitary, and not easily combined with any other, is met with also in certain fractures of the articular extremities; as, for instance, in those of the fibula, where it is an epiphenomenon of rotary displacement. It is especially common in transverse fractures of the patella; and then it is essentially due to muscular action, although a bad position of the limb may greatly increase it.

To sum up, we see that the causes of all these displacements may be divided into four kinds: the exterior cause of fracture; a bad position, enough of itself to disarrange the fragments, and aided by the weight of the body or of the limb; external forces acting on the broken bone, as when the patient, wilfully or while delirious, himself puts the apparatus out of order; and lastly, muscular action. The

first cause acts but for a moment, and its effects can always be remedied except in cases of loss of substance by comminution or crushing of the bone. The second is more permanent, and demands careful watching during the whole period of treatment; but this also is an accident, as it were passive, and can nearly always be avoided or corrected. The third requires likewise some care in indocile subjects; in insane patients I have more than once had to resort to forcible restraint; but these exceptional cases do not involve the same degree of responsibility to the surgeon as others do. There remains the fourth, unceasingly and actively counteracting our endeavors, always to be dreaded, and sometimes invincible—muscular action. It is therefore essential to determine with the utmost possible exactness what is its nature, and under what conditions it comes in play, in order to use the necessary means of combating it.

The muscles act on the fragments of a broken bone by momentary contractions, or by incessant tension.

Their contraction is voluntary, semi-voluntary, or entirely involuntary. Voluntary contractions are seldom met with but in insane or completely unmanageable patients; it is, however, well to forewarn such patients of the danger resulting, in order more easily to persuade them to keep the limb at rest. There is, in some fractures, a period when one may easily study the effects of voluntary contraction; I allude to those instances, happily rare, in which the fragments remain ununited and independent of one another; these will be again discussed in speaking of Terminations.

Semi-voluntary contraction is generally brought on by attempts to elongate the limb, which of course stretch the muscles. The pain thus induced appears to impel the muscles to resistance by contraction, although the influence of the will is made manifest by the effect of diverting the mind; by distracting the attention of the patient, and fixing it clearly and steadily on some other object, we greatly lessen, or even destroy the muscular resistance. Dupuytren attached great importance to this means in the reduction of luxations; and perhaps it is too much neglected in treating fractures.

Lastly, the irritation is sometimes so high, and the pain so intense, that the muscles are affected with convulsive contractions, recurring at intervals; these have received the name of *subsultus*. It is vain to seek to overcome this action by main force; the surest plan is to combat the irritation and wait for its subsidence.

The contraction assumes, then, two forms: sometimes it is voluntary or physiological, and may be obviated by diverting the patient's attention, by appealing to his self-command, or finally, by the employment, if needful, of a superior force; sometimes it is involuntary or spasmodic, depending on an irritation which must be subdued first of all.

The same distinction may be made in regard to *retraction*, [or

steady tension,] except that this is always involuntary. Sometimes it is purely physiological, and is then limited in extent and easy to overcome; sometimes the irritation, rising to a pathological state, exceeds all bounds, causes a shortening twice or three times as great as natural, and resists with incredible force any efforts to overcome it; such efforts even increase it, by exciting the fibres to convulsive contraction. I have particularly examined these two varieties of retraction in my *Anatomie Chirurgicale*, and will not here repeat the details there presented. I would, however, again say that any muscular action, of either kind, can only be combated to advantage when reduced to the limits of a physiological state; and that when the irritation rises to a pathological degree, we must wait for its subsidence.

This will be further practically applied in the article on Treatment; let us now examine how far displacements are due to muscular action. The question will repay the trouble of its discussion, so much the more that the solution at present received seems to me at variance with the results of strict observation.

It is generally stated that the majority of displacements are produced by the muscles; so that, a fracture occupying a given point in any bone, according to this theory we may foretell the displacement which will ensue. So far has this been carried that an English writer, Hind, wishing to show by a series of plates the causes of displacement in fractures of the extremities, could find no better plan than to delineate the bones and muscles of a dead body, making the latter pull on the former according to the seat of fracture;* never dreaming that the Hunterian Museum, some paces from his amphitheatre, would have utterly contradicted in advance his fantastic representations. I have severely criticised, in my *Anatomie Chirurgicale*, these false applications of pure anatomy to pathology; and without referring the reader to our public museums, my drawings will suffice to show all that is requisite, and all that is to be dreaded.

No, in the great majority of cases, the course of things is not as is stated by anatomists; the muscles alone have not so much power as is claimed for them, and they meet with many obstacles which they cannot overcome. The impulse given by the cause of fracture, the direction of the fracture, the impaction of the serrations, the resistance of the periosteum, and other soft parts, the position and the weight of the limb, mainly determine the nature and extent of the displacements; only one of these latter can be under the almost isolated influence of muscular action; I allude to overlapping. But it must be remembered, that then it is not one or two muscles which act on the fragments, but the whole muscular mass surrounding the

* G. W. Hind, *A Series of Twenty Plates, Illustrating the Causes of Displacement in the various Fractures of the Bones of the Extremities;* lith. in folio, London, 1835; analysed in the *Medico-Chirurgical Review*, Oct., 1835.

bone; and that the overlapping, by burying still more the broken ends in the flesh, causes almost always an irritation raising the contraction to a pathological degree. On the contrary, when a fragment is pulled upon by only one or two muscles, we may say that it yields to their action only as far as it is entirely free, and unopposed either by the direction of the fracture, by the resistance of the periosteum or of other muscles, or by the weight of the limb. I have had drawn (*Fig.* 33) a magnificent specimen of fracture of the cervix humeri, in which the upper fragment was brought into complete abduction by the supra-spinatus muscle; but then the violence of the blow had driven the lower fragment far into the axilla, destroying all connection, by means of the periosteum, with the upper one. But in this very sort of fracture, if the fragments remain ever so slightly in contact, if the periosteum be not entirely torn asunder, the displacement does not occur; and this is far more frequently the case.

From these considerations result two consequences of great practical importance, viz., (1) that every displacement, except overlapping, may be reduced and obviated, if only the fragments afford a sufficient hold; (2) that overlapping is the most stubborn of all. It is a disagreeable truth, generally too much kept out of sight by the classical authors, that overlapping is so stubborn as to baffle the efforts of art to overcome it, in the immense majority of cases.

(8.) *Crepitation* is the sound produced by friction of one fractured end upon the other. According to this simple definition, it may be easily seen that crepitation will fail to occur in many cases. If, for example, the surfaces are so closely held in contact by their serrations and by the integrity of the periosteum, that their rubbing is hindered, crepitation will not take place; as happens in many serrated fractures without displacement. If, on the other hand, the surfaces are so separated that they cannot be made to approach one another, crepitation will again be wanting; this occurs in fractures with very marked overlapping, when the fragments lie side by side; or when the contact is between the side of one fragment and the fractured surface of the other, as in intra-capsular fractures of the cervix femoris. I may just allude to cases in which a mass of blood-clot, a bit of muscle, or any other body, is interposed between the two fragments, hindering their direct contact. But to all these exceptions must be added fractures by crushing, which rarely give an appreciable crepitus; fractures with penetration, of which the same may be said; fractures of one of the two bones of a limb, etc.; and it may hence be seen how inconstant and how fallible this symptom is in a large number of cases.

On the other hand, the more numerous and easy the rubbings of the fragments, the clearer and more distinct is the crepitation. Thus in splintered and comminuted fractures, the least movement im-

pressed on the part, the least pressure at the seat of fracture, will cause a sound loud enough to be heard by the surgeon, the patient, and the by-standers. Generally in simple fractures neither pressure nor irregular moving of the limb will suffice; it is necessary to make certain motions, according to known rules. Thus one fragment must be fixed, and motion given to the other, or both must be grasped and moved upon one another in different directions. If the size of the limb permit, the surgeon takes hold of it with his two hands; if not, the upper fragment should be fixed by an assistant, the surgeon merely managing the lower one. It is well then to place the fingers of the left hand over the seat of fracture; I have even thought proper sometimes to commit the entire motion to assistants, in order with both hands to examine the suspected injury.

It is generally recommended to move the fragments laterally; but we should bear in mind that frequently this manœuvre fails, and others succeed better. Thus in fracture of the cervix humeri, rotation alternately inward and outward will be the surest plan; in fracture of the neck of the femur, flexion and extension, adduction and abduction, likewise made alternately, are preferable. In some cases, if the surfaces are too closely pressed against one another, they will not have sufficient play, and must be separated somewhat by proper traction. In other cases they are too far apart, as in fractures of the patella; and then they must be brought together.

With all these precautions, it frequently happens, first, that crepitation is absolutely wanting, as under the circumstances before mentioned; then, in more favorable cases, it may be slight, momentary, doubtful; again the surgeon may be uncertain whether the crepitation is really osseous, or only an emphysematous crackling, a rubbing of the tendons in a congested sheath, or lastly the click of a joint, stiffened, inflamed, or deprived of its cartilage. Boyer has declared that an experienced surgeon can easily avoid these errors; and in fact, bony crepitation, when clear and distinct, has characteristics distinguishing it perfectly, especially from the crackling of tendons or from emphysema. But when it is feeble and obscure, and needs to be diagnosed from the click of a joint, there is much more difficulty; for my own part, I have been in doubt several times, and several times have seen Dupuytren himself hesitate. M. Lisfranc conceived that the stethoscope would clear up everything, and even published a special memoir on this subject.* But surgeons know well that crepitation reveals itself rather to the hand than to the ear; or rather that it is transmitted from the hand to the ear more certainly than in any other way. As for myself, I have never heard by means of the stethoscope crepitation which I had not other-

* Lisfranc, *Mémoire sur de Nouv. Applic. de Stéthoscope.* Paris, 1823; reproduced in the *Clinique Chirurgicale* of the same author, tome i, p. 51.

wise perceived; and although I would not prevent its use by others, I have myself abandoned it.

Lastly, there are cases in which crepitation is remarkably clear at one moment, at another entirely wanting; the best planned movements do not elicit it, while those made at hap-hazard succeed; moreover, the same movement which produces it at one instant will fail the next. It is frequently impossible to decide where it occurs; thus for example, I once attributed to the fibula a crepitation of this kind, which really belonged to the calcaneum; and many such mistakes are made. I have but one remark to add here; it is that the crepitus is not equally perceptible at all periods of a fracture; its detection being frequently impossible until the inflammatory swelling subsides, and equally so after the callus begins to be organised.

ARTICLE IV.

COURSE AND TERMINATIONS.

This portion of the history of fractures comprehends the study both of the exterior phenomena, and of the more obscure processes going on within the tissues.

§ I.—*Of the Exterior Phenomena.*

We have seen in the preceeding article what were the most usual symptoms of fracture, immediately upon its occurrence; we must now follow its subsequent stages, whether of improvement or of aggravation. We are concerned at present only with simple fractures; the other forms are better studied by themselves.

The simplest fractures are frequently unaccompanied by contusion or great pain; they cause no inflammatory swelling; in a word, the patient is made aware of the injury only by the loss of firmness of the limb, and by the pain felt from certain movements. By perfect rest, maintained during a time varying in different cases from fifteen days to a month or six weeks, reunion silently occurs, and the fracture leaves no trace; in order to this it is manifestly requisite that the fragments should remain in exact apposition.

Even if the broken ends are displaced, it may still happen that no inflammation supervenes. During a period varying according to the age of the person, and the bone affected, the fragments seem to remain free, and as it were floating among the muscles; after this they gradually lose their mobility; they are now felt to be enveloped in a sort of tumor, not involving the more superficial tissues, slightly sensitive to pressure, but without either redness of the skin or ge-

neral reaction; the patient eats, drinks, and sleeps as usual; the inflammation cannot be said to exceed that in the other case. This tumor gradually hardens, finally assuming an osseous consistency; it is now impossible to produce the least motion of the fragments; consolidation is effected; but there will always be a double trace of the fracture, to wit, the abnormal projection of the fragments, and the prominence of the osseous tumor enveloping them.

It is by no means always the case that things go on so favorably. Whether the fracture be with or without displacement, but much oftener in the former case, it is from the beginning attended by notable swelling of the surrounding soft parts; this is due at first to effusion of blood, but is maintained or even increased by actual inflammation. Sometimes, if the bone be deeply placed, the inflammation will not involve the skin, this retaining its natural color; but the limb is swollen, tender, hot and painful; the patient feels it continually throbbing; and to these local symptoms there is often added a general reaction, an actual traumatic fever, with thirst, loss of appetite and sleep, and increased action of the heart. If the bone be more superficial, the skin itself reddens, swells, and is seen by the most inexperienced eye to be inflamed. This inflammation sometimes goes off in two or three days; sometimes it lasts till the fifteenth day, but generally it has disappeared by the seventh. Then the fever subsides, the redness and swelling abate; but the tumor around the fragments is somewhat larger than in the two preceding cases. This tumor gradually grows firmer, and may at the same time be felt to diminish, and to involve to a less degree the surrounding tissues; but it never entirely disappears; for though it is true that in fractures which are kept very accurately in apposition, one cannot detect during life the slight thickening around the broken ends, still upon dissection it may easily be shown by sawing open or merely by feeling the bone.

In comparing these two different modes of accomplishing the same object,—the consolidation of the fracture,—it must be remembered that in divisions of the bones, as in those of the soft parts, reunion may take place without inflammation, by a simple reparative process; while at other times there is added an actual inflammatory condition, which cannot safely pass beyond the adhesive stage. These are the ideas of John Hunter, and I accept them without reservation.

The period requisite for complete consolidation should be first studied, and afterwards that of each stage, above described, of the reparative process. The former varies with the age, with the bone involved, with the character of the fracture. All that can be said on this point is that in very early infancy, less time by one-half is required than in adult age; it has been asserted that union is much more tardy in old age, but I must say that this is not confirmed by careful observations of the fractures in old people treated by me at

Bicêtre. Nor can I discover any difference depending on sex, or any referable to the seasons. I speak now of fractures comparable with one another, that is, occurring in the same bones, and under the same conditions; a fracture with displacement cannot be so solidly united in the same time, as one kept in perfect apposition, and fracture of any one bone is sooner united when at one end than when in the shaft.

In this respect different bones present notable differences. Usually the bones of the lower extremities are more slowly consolidated than those of the upper, and these latter more slowly than those of the face. Doubtless, greater firmness is requisite in those which have the weight of the body to support; and especially in those which alone form the skeleton of the limb, as the femur and the humerus. Doubtless also the size of the bone should be taken into the account; thus it is not strange that the tibia should require more time to unite than the humerus. But aside from these considerations, I have been led to infer, from what I have seen in both the living and the dead body, that consolidation actually takes place more slowly in the bones mentioned; this has been most conclusively proved to me by the comparison of extra-capsular fractures of the humerus and femur, of the lower end of the radius and of the calcaneum.

Moreover, it should be added that the exact period requisite for consolidation, even fixing all the conditions of the patient and of the fracture, cannot be assigned; and that for safety to the surgeon and his patient, a longer time should always be allowed than is strictly necessary. This explains the apparent contradictions of practitioners, some demanding as much as two or three months for the consolidation of fractures which others declare to be cured at the end of six or seven weeks; and sometimes surgeons have erred from timidity, sometimes from temerity. I shall carefully discuss, in treating of each fracture, the contradictory opinions, and seek to give the most precise results of experience.

As to the other question of the distinction of periods in the reparative process, it seems to me that there may be marked out three such, each comprising one-third of the time requisite for complete consolidation. The first is entirely preparatory; nature is occupied in absorbing the ecchymosis, lowering the inflammation, and secreting matters necessary to union. In the second, these materials are organized, forming around the broken ends a gradually solidifying envelope, in which, however, the process of ossification cannot yet be clearly traced. The third is entirely devoted to this latter process, subsequent to which I do not believe that there is any other; the application of this remark will be seen when I come to speak of the theories put forth concerning the development of callus.

But all is not completed with the consolidation of the fracture; other phenomena arrest our attention or call for our interference.

The limb is more or less wasted, from disuse; the skin is dry, wrinkled and scaly. The muscles fulfil their functions but feebly at first, the movements are vacillating, and the patient instinctively feeling the weakness of the limb, does not for some time trust himself to it. I am not now speaking of those grave cases in which the muscles are encroached upon by the callus, and have irreparably lost their power. If the horizontal position has been long maintained, the limb swells and reddens if allowed to hang down. Sometimes, also, whether from bad treatment, or as the result of some complication, there remains in the cellular tissue an œdema more or less firm and persistent.

Until recently, no attention was paid to the state of the nails, in the growth of which Dr. Guenther claims to have discovered certain phenomena which constitute a certain and therefore valuable sign of the consolidation of the bone. He was led to this discovery by accident; a young man, with a very oblique comminuted fracture of the right leg, remarked that the nails on the right foot did not grow like those on the left; he informed the doctor, who thenceforward examined the nails daily with the greatest care; by the fiftieth day the nail of the little toe was found to begin to increase; a little later, those of the three next toes, and finally, after some weeks, the nail of the great toe. With this growth came the sensation of firmness in the limb, and consolidation was actually complete. After 1832, the date of this observation, the doctor claims to have seen many similar cases, and he concludes that in fractures of the extremities the arrest of growth of the nails is a constant phenomenon, persisting until union is definitively established.*

I first endeavored to substantiate this statement in two patients affected with fracture of the humerus and of the radius, without displacement; consolidation was only begun, but the nails were alike on either side. I attempted a more strict experiment on an adult patient who had an oblique fracture of the humerus, with overlapping and active inflammation. He was directed not to trim his nails, and these were most carefully measured with a compass on the second day, on the twenty-first day, and lastly on the thirty-seventh, some days before the completion of consolidation. The nails grew alike on the fingers of the injured and sound sides; and Doctor Guenther was certainly the dupe either of his patient or of his own imagination.†

But we must give much more serious attention to the effects produced on the joints, whether by the fractures themselves or by their treatment. Perhaps there is not a single fracture which can be considered cured merely because consolidation is complete; for, if by

* *Gazette des Hôpitaux*, Nov. 24, 1842.
† See my *Journal de Chirurgie*, Feb., 1842.

the word *cure* we mean the restoration of the functions to their normal state, the fact is that the stiffening of the joints hinders the functions of the limb for a much longer time than is required to unite the bone. I have seen fractures of the neck of the humerus, treated by myself with the utmost care, prevent the return of the arm to its functions for two or three months. I have seen a patient under the care of Boyer, who could not walk freely for a year after being dismissed as cured of a fracture. I have seen old persons, discharged from the hospitals as cured of fractures of the cervix femoris, unable to go without their crutches, four or even seven years afterwards; I have seen one who, twenty years after such a fracture, had not yet recovered the free flexion of the knee;* and I shall have to mention similar cases in connection with nearly all fractures. Stiffening of the joints is then the last consequence, the most persistent of the consecutive phenomena of these lesions; and it is not till after its disappearance that the limb entirely resumes its normal functions.

This result, however, cannot be attained at all except in fractures with little or no displacement; slightly marked as may be the overlapping or any other form of derangement of the bone, the patient is condemned to keep all his life annoying reminders of his fracture, such as deformity, impaired function, weakness, or even loss of certain motions, in the limb.

The deformity varies in form and degree, according to the nature and extent of the displacement. Sometimes it is an unpleasant prominence, as in the majority of fractures of the clavicle; sometimes an unsightly enlargement of the limb, as in some fractures of the humerus; or an angle in a limb which should be straight, as the leg or thigh; or a deformity about a joint, as in fracture at the elbow. Shortening is at once a deformity and a cause of diminution or loss of power; in the lower extremity, it leads to an almost inevitable limp; in the forearm, it hinders pronation and supination; we shall see that even in the clavicle, overlapping is more injurious than is usually stated, from its effect on the freedom of motion of the shoulder. At the same time, power is lost; no man whose leg is shortened can carry so heavy a burden as before; and lastly, as examples of absolute loss of some movements and even of all of the important functions of the limb, we may cite the consolidation of both bones of the forearm, [one mass of callus being formed,] and the occurrence of union with the fragment at a nearly right angle, in the leg or femur; of which specimens may be seen in almost all extensive museums. Deplorable consequences these, whether of the fracture, of the absence of treatment, or even of the treatment itself; but which, aris-

* Malgaigne, *De quelques dangers du trait. ord. des fractures du col du fémur; Bulletin de Thérapeutique*, Aug., 1841.

ing from whatever cause, constitute an essential part of the history of fractures, and a part far too much neglected.

It would be well if this were the worst termination we had to fear. But even in the simplest fractures it often happens that there is no consolidation; it may be that the treatment is inefficient, the surgeon giving up in despair, as in intra-capsular fractures of the femur, and in the majority of fractures of the patella; he may have been ignorant or negligent; or lastly there may have been, spite of the wisest precautions, a general or local disposition preventing osseous union, and leaving the patient only a weak and powerless limb, a broken lever in place of a firm one. I have seen these defects of consolidation in all degrees, in the living subject; in a patient affected with fracture of the lower fourth of the femur, the fragments, although movable, were so interlocked that of thirty-six acupuncture needles successively introduced, not one entered between them. I have on the other hand seen in a little girl, two years old, an ununited fracture of the condyles of the humerus, in which the fragments were separated more than a finger's-breadth; and lastly I have recorded the observation, at Bicêtre, of an old fracture at the middle of the humerus, the upper fragment of which could be raised horizontally by the deltoid, while the other hung freely at its extremity; by pinching the arm in the interspace, the skin of the two sides could be so closely brought together as to leave between them only about a finger's-breadth, within which the brachial artery could be felt beating.

Finally, it sometimes happens that a fracture, without any lesion of the integuments, is attended by suppurative inflammation, giving rise to immense abscesses and sinuses; or perhaps that an obstinate fragment, bearing against the skin, at last causes gangrene, thus admitting the air to the seat of fracture; or even that from the very first, owing to the original violence, the skin is torn so as to expose the fracture; and in all these cases we have not only to fear exfoliation of the bones, slow formation of callus, or necrosis of the fragments, but even worse accidents than these; such as stripping up of the skin and muscles; phlebitis, perhaps requiring the sacrifice of the limb; or still graver symptoms, such as extensive phlegmonous inflammation, intense fever, nervous delirium, tetanus, seriously endangering the patient's life; and lastly purulent infection, which is almost invariably fatal.

We have not to trace the history of all these complications, which are only so many new disorders superadded to the fracture, this latter being strictly only the exciting cause; still it belongs to our subject to study at least the mode in which the callus is formed in these difficult cases, as well as to show the reciprocal influences of the fracture and its complications; for this concerns both the prognosis and the treatment. But we have not yet come to this; the external pheno-

mena which have been thus rapidly sketched have their causes and their rationale, which remain to be explained; there is first the whole theory of callus, comprising two different subjects; that of its origin, whether in simple or compound fractures, and that of its transformations; there is then the theory of consecutive false anchyloses; and lastly there are the causes of non-union, or the theory of false joint. We shall therefore arrange under four separate heads what remains to be said concerning the terminations.

§ II.—*Of the Formation of the Callus.*

Perhaps no other question in surgical pathology has been so often agitated, or so variously solved, as that of the formation of callus. The oldest idea is that which attributes it to the marrow, considered as the aliment or nutritious juice of the bone; *medulla ossis alimentum, ideo callo firmatur.* Galen, rejecting what this theory had too much assumed, regarded the callus as due to the excess of nutritious juice brought to the bones by the blood, over that sent to all other parts; and these two views, the Hippocratian and the Galenian, had each its supporters until the beginning of the seventeenth century; at which time, a very animated controversy arising on this point between Lanay and Jacques de Marque, the latter demonstrated logically that the marrow could not of itself furnish the materials for the callus.* From that time, Galen's theory obtained the preference, and we find it still in favor late in the eighteenth century, even when experiment would seem to have contradicted it.

In 1684, Antoine de Heide, studying the callus in frogs, arrived at the quite novel conclusion that it was the result of coagulation of the blood effused around the fragments. In 1741, Duhamel attributed it to the ossification of the periosteum and of the medullary tissue; Haller and Dethleef, followed by Troja, placed beyond doubt the secretion of an ossifiable plastic lymph, which formed part also of the theory of Galen; Bordenave, agreeing with them concerning the effusion of this lymph, concluded nevertheless that the bone became reunited by means of its vesicular tissue; Camper believed that the interior osseous fibres of each fragment were so prolonged as to meet one another; J. Hunter revived, in a somewhat more general form, the hypothesis of Antoine de Heide; Manne and Bichat imagined the callus formed by granulations; and lastly M. Breschet has united the two principal theories, ascribing the origin of callus to blood and lymph combined.†

* Hippocrates, *De Alimento;* Cassii Iatrosophistæ *Questiones, quæst,* 58; Galeni, *Comm. I in libro de Fracturis; Comm. I de Articulis; Methodi Med.*, lib. vi, cap. v; J de Marque, *Paradoxe ou Traicté Médullaire,* Paris, 1609, 12mo.

† Antoine de Heide, *Anat. mytuli; subjecta est cent. Obs. Med.,* obs. 57;

We say then at once that the theory of granulations, however specious as regards fractures exposed to the air, is deprived of all foundation when applied to ordinary cases; that the prolongation of the osseous fibres is only seen in callus in a very advanced stage, and never at the beginning; that Bordenave, introducing the vesicular tissue after having admitted the effusion of lymph, has taken for a primary and constant phenomenon one which is consecutive and quite rare; that Duhamel, who so carefully observed the engorgement of the periosteum and medulla, did not see that this was due to liquid effusion, whether of blood, or of lymph; and apart from all these theories, we shall confine ourselves to the only two actual doctrines which dispute the precedence; the old doctrine of the osseous juice, and the modern one of sanguineous effusion.

As I cannot profess much respect for the priority of Antoine de Heide and his experiments on frogs, I shall credit properly the following two principal theories: the first actually conceived by Galen, verified by Haller, Dethleef, Troja and others; the other coming essentially from J. Hunter, and submitted to experimentation by Howship and M. Breschet. What is especially remarkable is that they were not deduced from particular observations or experiments, like most others; but that they were proposed as it were *à priori*, or rather as consequences of more general ideas concerning the restoration of divided parts; Galen teaching that every solution of continuity was repaired by means of the nutritious juice proper to each part, and Hunter attributing the same function to effused blood. And if anything in this history would justly excite our wonder, it would be the sight of modern genius overcome by ancient, of John Hunter yielding to Galen.

The first phenomenon revealed by the scalpel at the seat of a fracture, is an effusion, more or less abundant, of blood; this is probably never wanting. For my own part, I have never failed to find it, and the opinions of Antoine de Heide, Duhamel, Howship and M. Breschet are unanimous on this point; we must doubtless ascribe to some singular preoccupation the entire omission of any mention of it by Dethleef, Haller, Fougeroux and Troja. We should, however, remember that when a fracture takes place with the least possible disturbance of the parts, the periosteum even remaining unbroken, the effusion is very slight; increasing in proportion to the injury inflicted on the periosteum, medullary tissue and muscles, by the

Duhamel, *Mém de l'Acad. Royale des Sciences;* Fougeroux, *Mém sur les Os*, Paris, 1760, 8vo; Haller, Dethleef, Bordenave, in the work of Fougeroux; Troja, *De nov. ossium regener. experimenta*, Lutetiæ, Paris, 1775, 12mo; Camper, in *Essays and Obs. of Society in Edinburgh*, 1771, vol. iii; J Hunter, *On the Blood and Inflammation;* Bichat, *Anat. Générale;* Howship, *Experiments, etc., in Medico-Chirurg. Transactions*, 1817, vol. ix; Breschet, *Thèse de Concours*, Paris, 1819.

separation and overlapping of the fragments. In the former case the blood is poured out in the medullary tissue at the level of the fracture, a little of it also passing between the fragments and beneath the periosteum; in the other cases, the effusion occurs in all the torn tissues, and even traverses the cellular tissue for a considerable distance.

After a time, varying with the age and species of the animal, commences the effusion of coagulable lymph, which seems gradually to take the place of the blood, the latter being reabsorbed, Dethleef succeeded in detecting this lymph at the end of eight hours, in a fracture of the humerus in a young dog; but at the end of twenty-four hours, it is unanimously testified to by Duhamel, Fougeroux, Troja and M. Breschet. It is singular that Howship alone did not perceive this, though very earnest in his examination of the clot; a preoccupation fully equal to that of the partisans of the other theory. Troja has studied with the microscope the effusion of this lymph; he has seen it poured out in the form of small grains, first between the fractured surfaces, and then between the periosteum and the bone; but other experimenters have been satisfied with the naked eye. It finally infiltrates the periosteum; and this result once attained, Duhamel fixes on it to the exclusion of everything else; but Dethleef shows that it is actually the lymph which does this, and M. Breschet has since established the occurrence of the same infiltration in the surrounding cellular tissue, as far as the sheaths of the muscles, provided there is a passage given it by a preceding rupture.

The lymph, once thrown out, is soon coagulated, and the formation of its vessels begins. At the fourth day, in a young dog, Dethleef observed red points in the midst of the coagulable lymph, and considered them as so many centres of commencing ossification. Troja, from the fourth to the seventh day, found the fractured ends joined by numerous fleshy fibres, which, if torn across, left only red points on the bony surfaces; but examined with good microscopes, these points appeared concave, assuming the aspect of torn vessels. M. Breschet showed, on the second day, the presence of red points on the fractured surfaces; he thought them formed of blood, and that from their development came the red, softish, filamentous substance, observed both by him and Troja from the fourth to the sixth day. Thus we see three explanations of the phenomenon: points of ossification, newly formed vessels, or fibrinous tissue. Howship seems to have solved the enigma. At the fifth day, in a rabbit a year old, a very fine injection filled in a surprising manner the vessels of the cellular tissue, of the periosteum, and of the marrow; to explain the participation of the cellular tissue in this vascularity, it should be stated that the fragments were overlapping. At the point where the fragments overrode one another, there were found between the periosteum and the bone evidences of an osseous secre-

tion, in the form of a white, rugose deposit, visible with the microscope. Thus the commencement of ossification is here placed beyond doubt, and the white or red color of the bony points is of small importance; but how are we to explain this ossification, seen by Howship at a time when, as he says himself, no vessel yet penetrated the clot? Evidently the callus had commenced outside of the clot; its whiteness forms another argument against their being in any way connected. It was not till the ninth day that the clot lost its coloring matter; but Howship has omitted to state how he ascertained that this blanched clot was actually blood, and not lymph. His observations, then, accord with those of all the other experimenters; but he was the first to follow the development of the vessels, finding them abundantly formed, first in the periosteum, passing obliquely from its inner surface to the bone, and afterwards in the medullary membrane. He adds that the innermost part of the clot, the portion lodged in the cells of the medullary membrane, is also filled with vessels; and this is the last prop of his theory. But M. Breschet, following him, has ascertained that the red substance called clot by Howship was a new formation of fibrous tissue, found likewise between the fragments themselves.

What need is there of further combating a theory which has not yet been supported, either as regards the soft parts or the bones, by any well demonstrated facts? English surgeons have vainly sought to find a single example of organisation of a blood-clot—that is, of its vascularisation; and they themselves oppose the doctrine of their great master.

To sum up, then, the callus is formed by an effusion of plastic lymph, probably secreted from the periosteum and medullary tissue, perhaps also by the surfaces of the fracture; this lymph infiltrates the adjoining tissues, but especially the periosteum and medulla; afterwards it is organised, becoming penetrated by blood-vessels, and takes the place of the clot, which is absorbed. It is worthy of remark that a very considerable effusion of blood is an obstacle to consolidation.

So much for simple fractures, or such as are not exposed to the air; as to such as are so exposed, whether by the original injury wounding the soft parts, or by suppuration, I know of no one who mentioned them before John Hunter; and this great observer, comparing them with suppurating wounds of soft parts, thought that their consolidation was effected by granulations developed on the two fractured ends; which granulations became subsequently ossified. Dupuytren embraced this theory, which seems by no means in accordance with the facts. M. Breschet has made it certain that the obliteration of the medullary cavity follows the same course as in simple fractures, and that the ends of the external osseous ring do the same. Only he adds that granulations arise on the surfaces of

the fracture, on the uncovered parts of the ring, from the internal osseous pin, and lastly from the soft parts; and that in the bone and the callus this formation of granulations goes on by means of an intermediate layer of substance resembling cartilaginous, fibrous, or fibro-cartilaginous tissue.

I have fully recognised the justice of the first results obtained by M. Breschet, which of themselves suffice to shake the doctrine of Hunter and Dupuytren; but I do not allow so much importance to the granulations as M. Breschet would. From what I have been enabled to observe in man, the effusion of coagulable lymph always occurs where the air does not penetrate, and fills even the interstices of the fragments when these are so retained in position as to prevent the access of air. Granulations only arise in suppurating parts; so far from aiding consolidation, they are only produced at the expense of the bones, which are hollowed out or absorbed before them wherever they are developed. When, in the most complicated cases, suppuration has entirely laid bare the ends of the bones, and these are eroded and covered with granulations, it is necessary for reunion that a special effusion of lymph should occur between the opposing surfaces; and it is in this lymph that ossification takes place, and by it that the loss of substance is made up. On the contrary, when an osseous surface remains isolated, out of relation and without any possibility of union to the other surface, no new ossification ensues, and the loss of substance, filled up merely by granulations, always remains perceptible.

I shall cite as an example the compound fracture of the leg represented in *Fig.* 7. A woman, aged 50, was overthrown by the fall of a cask, breaking her right leg; the lower fragment of the tibia projected more than an inch through a large rent in the integuments. It could be easily reduced, but not retained in position; one portion became necrosed; gradually the granulations reached the limits of the necrosis, and all was going on well, when symptoms of purulent absorption came on, and proved fatal on the eighteenth day.

In the drawing is seen the lower fragment of the tibia, necrosed at its upper end. The edges of the necrosed portion are serrated, as if worm-eaten; and it may be added that below they are hollowed out to the depth of one or two millimètres. Between the edge of the necrosis and the sound bone is an interval three or four millimèteres wide on the inner, and three or four times as much on the outer side; in all this interval the bone is eaten away one or two millimètres below its natural level. The bottom of this erosion, in the fresh specimen, was composed of bony tissue, hard, but reddish, presenting longitudinal striæ separated by ridges; these ridges were redder and less firmly resistant to the scalpel.

The granulations are no longer seen; they constituted, over the whole extent of the eroded portion, a reddish, soft, slightly adherent

membrane, sending out fungous prolongations under the edges of the necrosed portion; on these latter doubtless devolved the function of detaching by absorption the whole of this large mortified part.

But at any rate, here the granulations stopped. As the necrosis had not invaded the entire thickness of the fragment, between the living portion of the fractured surfaces was a soft, tomentose, reddish-brown substance, adhering to all the corresponding parts of those two surfaces; if torn up, beneath it were reddish striæ similar to those found beneath the true granulations. The splinter was likewise united to the upper fragment, and this same red tissue had filled all the interspaces and angles between both fragments and the splinter; it jutted out even to the periosteal face of the latter, and there began to become ossified, without any trace of the formation of cartilage. This commencing ossification was entirely soft and spongy; some portions of it remained on the dry specimen, and hence appear in the drawing.

To any one who, not having seen the thing itself, can only judge from the description, a very natural objection will occur: was not this reddish tomentose tissue formed by the junction of granulations springing originally from each surface? But this very instance furnishes the most decisive answer; the two fractures of the fibula, one at least of which did not communicate with the external wound, were united by a similar reddish tissue, beginning to ossify in its most external layers. I shall before long have occasion to recur to this tissue.

There may also be remarked in the drawing the numerous porosities, occupying mainly the tibial splinter (except at the inner angle, where the necrosis was) and the lower fragment. These porosities, which show here and there little ridges, denote a superficial inflammation of the bone almost constantly found where a fracture is followed by suppuration. The more active the inflammation at the seat of fracture, the more widely extended are its traces on the surface of the bone; so that in gunshot-fractures the whole bone sometimes appears thus marked by porosities and ridges. Of this there is a fine example in the museum at Val-de-Grâce, in the femur of a Swiss wounded in 1830, who lived until the bone was completely consolidated.

[An excellent account of the process of repair of fractures is given by Paget, in his "Lectures on Surgical Pathology."]

§ III.—*Of the Transformations of the Callus.*

We have traced the callus up to the time when it is abundantly traversed by blood-vessels, and therefore already endowed with a complete organisation; but this organisation is merely temporary—a step toward ossification, the great end of the reparative process.

Surgeons have not studied this latter part of the history of the callus much better than the former.

The oldest idea, dating as far back as the "Prænotiones Coacæ," is that bones when broken do not again unite. Perhaps obscure in the writings of Hippocrates, it becomes very clear and positive in those of Galen. The latter, having studied the callus in different animals, having scraped off the newly-formed osseous matter, and found below it the fragments not yet joined, concluded that in the bones there was not, as in the soft parts, direct union; but only a sort of intermediate soldering of the parts, as when two bits of wood are held together by a ferrule. This comparison is in some degree just; and Galen himself had noted as an exception that in young subjects direct union might occur.

Modern authors have misconstrued Galen's comparison of the callus to a ferrule, understanding him to say that the former was not organised. But it might as well be inferred, because Galen compared the fragments to two pieces of wood, that he regarded the bones as destitute of life.

In giving the old doctrine its true meaning, we are justly surprised at the long course taken to return to this point of departure, and we see that we have added to it but very little. Thus Duhamel concluded from all his experiments that the reunion of the bones was only direct in very young animals; but attributing the main action to the thickened periosteum, he was the first to speak of the successive transformation of this into cartilage and into bone. The entire formation of the callus was thus comprised in three distinct periods. Haller went further, and making the callus originate in a gelatinous juice gradually thickened to a sort of jelly, ascribed to it three new transformations: (1) into cartilage; (2) into spongy osseous tissue; (3) into compact tissue. There was, then, a new period added to those of Duhamel; nothing else was changed except, as we have seen, the explanation of the original period; and Haller has even omitted in his theory the case of direct union. Dupuytren perceived this gap, and thought to fill it by instituting a fifth period, in which the fragments became united end to end, by a *definitive* callus; the four preceding periods belonging to the *provisional* callus. But as the definitive callus formed, the provisional, becoming useless, gradually disappeared, the bone thus returning to an entirely normal state. This theory of Dupuytren's, which completed the others, and seemed to account for all the facts, gained great favor, especially in France; to adapt it to practical wants, he has defined the duration of each period:

First period, *engorgement of soft parts*, first to eighth or tenth day.

Second period, *formation of cartilage*, tenth to twentieth or twenty-fifth day.

Third period, *formation of spongy bone*, twentieth or twenty-fifth

to thirtieth, fortieth, or sixtieth, according to the age, constitution and health of the patients.

Fourth period, *formation of compact bone*, fiftieth or sixtieth day to five or six months.

Fifth period, *formation of definitive callus*, completed by the eighth, tenth, or twelfth month.

There is one objection which holds alike against all these theories. André Bonn, without denying the cartilaginous transformation in animals, affirms that it never has been seen in man; in whom the callus, according to him, is first fleshy, becoming afterwards fibrous and like skin, and then passing at once into bone. Macdonald has observed that even in animals the callus may be reddened, while in the cartilaginous stage, by the use of madder, which is not the case with true cartilage; whence he concludes that the plastic lymph is directly transformed into bone, at first soft and flexible, and afterwards solidified by the deposition of calcareous salts. This explanation allows to the experiments all their force, but changes their interpretation; while Bonn's assertion would lead to their rejection as inapplicable in the case of man, and may hence be seriously disputed. Two questions arise: first, is it true that experiments on animals always show the cartilaginous transformation? secondly, is it true that this transformation is never seen in man?

We have already said that Dethleef claimed to have seen osseous grains at the fourth day, in a tumor which had not yet passed into the cartilaginous condition; and that Troja and M. Breschet had pointed out the existence, between the fractured surfaces, of a fibrinous tissue; the last-named observer has likewise seen it between displaced fragments, holding them together. Howship also declares that about the ninth day, while the osseous transformation is going on in the external tumor, which is entirely cartilaginous, it has commenced in the red tissue filling up the medullary canal, which, according to him, is the remains of the clot. It is true that neither Duhamel nor Dethleef make any mention of this red tissue; but they also pass over the effusion of blood, the reality of which is beyond doubt. Dupuytren says that the red tissue is sometimes wanting; but we have no details of his experiments, and it may be that he drew this conclusion from those of Dethleef and Duhamel. However this may be, there is seen even in animals an ossification occurring in an apparently fibrous tissue, without any cartilaginous stage; and this commencing ossification in the medullary canal is much more rapid than that of the external tumor. This latter, on the contrary, appears always to have a cartilaginous aspect, although wanting many of the characters of true cartilage, and essentially differing from it in having a tendency to ossify.

There remains the second question: Is it true that in man the callus never goes through a cartilaginous stage? A. Bonn would

think so, from all the observations made by him; and I should be of his opinion entirely, were I to speak here only from what I have myself seen. I have mentioned recently a case in which the callus, twenty days old, consisted of a reddish tomentose tissue, in which ossification had begun. I have elsewhere published an account of a double fracture of the femur, thirty-five days old, in a patient fifty-three years of age. There was as yet no attempt at union between the fragments, and, let this be noted, the delay seemed owing entirely to the too large quantity of blood effused; but between a large splinter and the upper fragment appeared a broad reddish membrane, already interspersed with points of ossification. Likewise in a man, aged 45, affected with fracture of the os calcis, who died on the forty-ninth day, the numerous intervals separating the fragments were just filled by a bony tissue, redder, softer, and less dense than the rest of the bone; and in several places the reunion was only accomplished by a soft, tomentose, and membraniform substance.* I cite only these three cases, adding, however, that in none of the autopsies in which I have been enabled to examine imperfect callus have I found any appearance of cartilage.

But I do not feel authorised to draw a conclusion as absolute as that of Bonn; and as my own experiments on animals have led me, like all other experimenters, to see the cartilaginous transformation, as also my autopsies have been only in adults or old persons, I ask myself if the animals we make use of do not represent the young human subject, and if in infancy there might not be found a cartilaginous period of the callus. A. Bonn himself has unintentionally furnished a fact in support of this presumption. He had, in the Museum of Hovius, the clavicle of a little girl four months old, fractured, half consolidated, and preserved in alcohol, without the periosteum. "This imperfect callus," says he, "by its external aspect, its whitish color, its hardness and elastic flexibility, resembled cartilage; but with a lens it was seen to have an outer layer of bone, fibrous, porous, grooved, entirely analogous to the osseous nuclei developed in the cartilaginous epiphyses of the long bones." This last argument of Bonn's loses all its force since we admit that even in animals there is only an apparent and not a true cartilage. In another child, three years old, rachitic, who died the seventieth day after a fracture of the femur, he found likewise the periosteum swollen, of a reddish-white color, and more, he says, like skin than like cartilage; and yet a lamella of this new tissue showed a cartilaginous translucence.† Here, indeed, there was a specimen of what M. Breschet, for instance, has designated in his experiments as fibro-cartilaginous tissue; and on the whole it appears that plastic lymph

* See the *Gazette Médicale*, 1836, p. 170; and my *Journal de Chirurgie*, tome i, p. 9.

† *Descr: Thesauri Oss. Morbos. Hoviani*, pp. 164 and 165.

in children takes the form of cartilage before ossifying, while in adult age it is organised into a reddish fibroid membrane, and from that passes directly into bone.

There is then, in this point of view, some objection to the majority of modern theories. Other no less serious difficulties exist as regards the fourth period of Duhamel and Dupuytren, viz., that of transformation of the spongy tissue of the callus into compact tissue, and the simultaneous formation of definitive callus.

Inquiring of experimenters in regard to this, we are surprised at the small number and the almost insignificance of their observations. Dethleef examined a fracture of the leg in a dog at the fifty-fourth day. The exterior callus was still partly cartilaginous; in the medullary cavity it was partly *dense*, partly *osseous* and *cellular*. Another fracture, involving both bones of the forearm, was dissected on the ninetieth day. The callus of the radius was spongy, and the fragments still slightly movable; the ulna, on the contrary, was so solidly joined, that on sawing it lengthwise the callus was only recognised from the red stain caused by the use of madder. Bordenave, at the forty-fourth day, found the callus externally redder than the rest of the bone; but he did not saw it open. Duhamel broke the leg of a lamb a month or six weeks old; at the end of two months he found it so well united that he could not distinguish the fragments. The same result was obtained in a lamb killed at the end of four months. All this by no means shows the transformation of spongy callus into compact tissue; and I know of no experiments more conclusive than these.

Now, do autopsies speak more plainly? We meet with three in Dupuytren's *Leçons Orales*, of fractures of the tibia and of the femur, examined after fifty-eight, eighty, and ninety-four days respectively. In the first the callus was spongy; but wait a little. In the second the callus is again spongy. Lastly, it is still altogether spongy in the third case; so that these three cases, belonging only to the third period, prove nothing as regards the fourth; and moreover, they show this third period to have been prolonged beyond the time assigned it by Dupuytren.

I have, however, seen fractures united by an entirely compact callus; I possess a very fine specimen of this in a fracture of the tibia, with slight displacement transversely, and have seen others in which the callus was compact at the exterior, forming a shell of greater or less thickness around the still spongy central portion. Doubtless it was a combination of cases analogous to these by which Dupuytren was misled; but scientific exactness cannot accept as complete and general a theory based on so small a number of facts. Here, then, is the real state of our knowledge in this respect:

In the great majority of fractures preserved in our museums, the callus is spongy; very rarely it is changed into compact tissue.

We do not know at all whether or not this transformation is constant, and much more probably it occurs only exceptionally.

We do not know at all the circumstances under which it occurs, or the time requisite to accomplish it; and the assertion of Dupuytren, fixing this as from the second to the sixth month, is entirely chimerical.

But at any rate, whatever may be the state of the provisional callus, is there always a definitive callus, or complete union of the fragments? Galen admitted its occurrence, but only in young subjects; it has been obtained in animals, where there had been no displacement. I would willingly believe that such is sometimes the case in human adults; but I must confess I have seen only the instance cited above, which might just as well be used to prove the compact ossification of the provisional callus. Sometimes I have seen the fragments, even in contact, retain a linear trace of separation without any kind of alteration (see *Fig.* 37;) sometimes I have seen the broken ends not only remaining ununited, but themselves presenting a spongy texture, doubtless from the effect of inflammation of their former tissue (see *Figs.* 36, 68, and 70.) I make no allusion here to fractures through the spongy portions of bones, where the callus is from the beginning assimilated to the continuity of the bone.

There remains, lastly, the fifth period, in which the provisional callus is superseded by the definitive or permanent. We see at once that in all cases where the fragments are too much separated to reunite end to end, definitive callus, as understood by Dupuytren, cannot be formed, and the provisional callus must become permanent. We see also that when the fragments, placed end to end, do not directly unite, the disappearance of the provisional callus can hardly occur, since it would reproduce the fracture. We see, therefore, that this fifth period is reserved for those rare cases in which there is no displacement, and a definitive callus forms; even then I should say that I know of not a single fact which could be adduced to prove the resorption of the provisional callus. Dupuytren himself has cited none; and so the theory is once more reduced to a pure hypothesis.

As regards the interior callus, M. Lambron has carefully examined all the fractures in the Musée Dupuytren, and those in M. Gerdy's collection; he has even had sawed open bones fractured years before, the external surfaces of which were perfectly regular, and has always found the canal interrupted at the seat of fracture, either by layers of compact tissue, or by a spongy network. Camper has always met with a *septum* of compact tissue; from this, indeed, he was led to state that the interior callus was formed by prolongations of the fibres of the diaphysis, meeting one another across the canal. I cannot for my own part be as positive as Camper, or even as M. Lambron. Most commonly, it is true, I have found the interior callus compact; sometimes spongy, as is beautifully shown

in *Fig.* 37; but I have had represented (*Fig.* 36) the callus, otherwise very irregular, of a humerus, in which the spongy tissue only very imperfectly fills the medullary canal, leaving a communication between the fragments. I would not hence conclude that here an interior callus had been absorbed, for there are fractures in which the interior callus is from the beginning very incomplete; and in *Figs.* 76 and 77 may be seen an exterior callus already partly ossified, but hardly any traces of an interior callus.

The same may be said of the external callus; M. Lambron asserts that it may disappear entirely, which is rare, or only in part, which is more common; but he himself admits that some fractures unite without any exterior callus; and Duhamel and Troja have found by experiment that in animals a compressing apparatus hinders the formation of the ring. When, therefore, we meet with a fracture consolidated without any such ring, we have no right to say that this latter has been absorbed, without first proving that it was really formed.

But in place of this hypothetical resorption, M. Lambron has studied another form differing from it both in cause and in results. The cause here is the compression or the motion of the muscles upon a superabundant callus; or rather upon the projection of the fragments themselves. "Thus," says this author, "one may see in the Musée Dupuytren several fractured femurs in which the superior fragment, overlapping the inferior, is transformed into a sort of spike, from being worn by the to-and-fro motion of the rectus femoris (in the flexion and extension of the leg) and laterally by that of the vasti."* These observations are very just. I have had represented (*Fig.* 73) a femur in my collection, in which can be plainly seen the wasting and thinning of the external wall of the shaft where the upper fragment was compressed by the vastus externus. *Fig.* 85 shows another femur in which the upper fragment, projecting forward, has been wasted by the pressure of the quadriceps. All sharp points are thus blunted or finally removed, according to the greater or less amount of pressure exerted upon them.

The doctrine of the formation of the callus may therefore be summed up in the following propositions.

(1.) The callus, taking its origin from an effusion of lymph, assumes at first the form of a reddish tissue, which passes afterwards into spongy bone. These are the three principal phases of the reunion of bones, and for this reason I admit in the living subject but three periods, corresponding to them as nearly as may be.

(2.) In young subjects the reddish tissue is in great measure replaced by a tissue of a fibro-cartilaginous aspect, which would perhaps be more properly called *fibro-gelatinous.*

* E. Lambron, *Thèse Inaug.*, Paris, 1842, No. 203.

(3.) The formation of spongy bone is the last phase of the callus in fractures of the spongy bones, and in the majority of other fractures. Sometimes, however, there is a transformation into compact tissue.

(4.) Immediate union, the rule in fractures of the spongy bones, is very rare in those of the diaphyses. The fragments in these latter appear under three different forms; sometimes enveloped in spongy callus, but without having themselves undergone any alteration; sometimes thinned out and pierced into cells connecting closely with those of the callus, or lastly sometimes joined end to end without any trace of the previous division.

(5.) In general the medullary canal is obliterated by a septum of compact tissue, or by a plug of spongy tissue. This obliteration occurs even when the fragments are entirely separated; it is seldom wholly wanting.

(6.) In general also the callus forms a ferrule more or less solid around the ends of the bone. Sometimes this is naturally wanting, especially in simple fissures; or its development may be hindered by means of pressure. But when once ossified, it is not reabsorbed; and all resorption of projections about a fracture is due to pressure by muscles or other surrounding tissues.

All this, however, applies only to bony fragments endowed with a certain degree of vitality; it gives us no information concerning either splinters, or fractures involving articular cartilages.

John Hunter was the first to study the subject of splinters. In simple fractures (without any external communication) he had seen that they contracted adhesions, and lost by absorption their asperities. MM. Breschet and Villermé have made some very curious experiments on this subject, with the following results.*

Splinters having no vital connections, if of a certain size, always determine inflammatory symptoms, in consequence of which they are expelled, unless life should be destroyed; when very small, they often remain in the part without serious inconvenience.

After a month, in the case of dogs, these little splinters, ordinarily imbedded in the substance of the forming callus, had undergone no sensible change, but presented the same aspect as on the first day. At the end of two months one could still recognise the outer and inner surfaces of the cylinder of which they had formed part; but these surfaces were roughened, and the fractured edges were thinned, showing here and there little points not seen in the recent state.

At four months, the thickness was everywhere diminished; the edges sharp, undulating, with points of greater or less length and

* *Des Esquilles qui Compliquent les Fractures; Journal de Physiologie Experim.*, tome i, p. 116. This memoir alone bears the name of both authors; but M. Breschet has in several passages said that the experiments for his *Thèse de Concours* were likewise made in common with M. Villermé.

sharpness; opposite a very long point there was generally on the other edge likewise one longer and larger than its neighbors. The inner and outer faces could no longer be made out except by the general curvature of the fragment. Sometimes at this period there were seen very small, elongated, thread-like splinters, which certainly had not been detached in this form.

Moreover, some time after the fracture, the splinters were always found imbedded in a red, softish tissue, essentially vascular, and very easily injected.

Hitherto we have no evidence that the course of things is otherwise in man, except perhaps that in adults the splinters resist absorption for a longer time. I have had drawn (*Fig.* 8) the splinters from a gunshot fracture of the tibia, received in 1815, which were extracted in 1823, eight years afterwards; all these splinters are white, compact, and appear irregularly hollowed out in the thickness of the wall of the shaft. In the two larger ones, the inner and outer surfaces can be easily distinguished; the latter has been hardly at all affected by absorption. The largest of all is traversed on its outer face by a spiral fissure, involving only a portion of its thickness.

Gunshot fractures, which usually give rise to a good many splinters, are frequently consolidated without the expulsion of these; but the patients are apt to have pains, inflammation, and small abscesses about the seat of fracture; and every occurrence of this kind is ordinarily terminated by the discharge of a few splinters. I have seen several soldiers who carefully preserved scores of bits of bone, thus expelled from time to time even after fifteen or twenty years.

There is, however, a distinction to be made among these splinters, which is clearly defined by Dupuytren. Some, dating from the moment of fracture, are detached by the original violence; these are *primary;* others, called *secondary* by Dupuytren, are the result of necrosis of the broken ends, and are separated from the bone by an eliminative inflammation. But this distinction, although theoretically correct, is hard to make in practice when a certain time has elapsed since the occurrence of the injury; for instance, I would not venture to say whether the splinters in *Fig.* 8 were primary or secondary.

As to fractures of the articular cartilages, there has never been seen in them even an attempt at reunion. *Fig.* 79 shows a division of this kind, in the cartilage of a patella which is itself well consolidated. The drawing was made from the specimen after its maceration in water for the purpose of softening the cartilage, the separation of the borders of which, in the dry state, was much more marked; giving the idea of a much greater loss of substance than had really occurred.

The mode of union of the costal cartilages will be discussed in another chapter.

[In the chapter on "The Repair of Fractures," in Paget's "Lectures on Surgical Pathology," will be found an admirable discussion of the subject of this section.]

§ IV.—*Theory of Anchylosis following Fracture.*

This question, upon which the authors of the last century hardly touched, is perhaps still somewhat undecided. J. L. Petit alleged that in fractures bordering upon or involving articulations anchylosis ensued from the deposition of callus either within or about the joints; in others he attributed it to thickening of the synovia, from want of motion. To this thickening was added by Duverney the stiffness or contraction of ligaments and muscles. Boyer drew a distinction between the anchylosis produced by immobility, and due at the same time to a lessened synovial secretion, that due to stiffening of the ligaments and muscles, and that due to engorgement of the surrounding soft parts; according to this author, a slight amount of inflammation, added to want of motion, led to adhesions like those of serous membranes; and he proved by dissection that the inspissation of the synovia and the intra-articular formation of callus were matters of pure hypothesis. These ideas, going back as far as J. Hunter, were quite generally admitted until a pupil of the Lyons school, M. Teissier, endeavored to rectify them, and to show that want of motion alone, unconnected with inflammation, could induce:

(1.) Simple and purely muscular stiffening of joints.
(2.) Effusion of blood or of serum in the articular cavities.
(3.) Injection of the synovial membranes, and the formation upon them of layers of lymph.
(4.) Alteration of the cartilages without adhesion of the articular surfaces.
(5.) Fibro-cellular anchylosis.

This doctrine is based on five observations, which deserve examination.*

The first was in a man aged 60, with an oblique fracture at about the middle of the femur; he died at the end of three months, extension by means of Boyer's apparatus having been constantly kept up throughout this time. He had had no pain in the articulations. Nevertheless it was found at the autopsy, that the knee-joint of the affected side contained a large quantity of effused blood; the cartilages were here and there destroyed to one-half or the whole of their thickness, by ulceration, around which there was some injection; they were easily detached from the bones, which were unaltered. The tibio-tarsal articulation displayed also an effusion of blood, its

* *Gazette Médicale*, 1841, pp. 609 and 625.

cartilages were yellowish and had lost their polish, and the synovial membrane was thickened and injected.

In a woman aged 70 years, who died at the sixty-eighth day after a fracture of the cervix femoris, treated with Desault's splint, there was likewise found an effusion of blood in the knee-joint; the cartilages were roughened, yellowish, injected, eroded at various points; the synovial membrane seemed infiltrated with blood; the lateral ligaments engorged, and imbedded in condensed cellular tissue. The third case, analogous to these two, was one of fracture of the cervix femoris treated by extension, and examined five months after the accident.

Such then are the marked alterations found from the second to the fifth month after the fracture. The other two cases go to show the effects of loss of motion prolonged from fifteen to twenty-two months.

A man of thirty-six sustained, at about the lower third of the left leg, a comminuted fracture, which was complicated by suppuration, necrosis, and the formation of fistulæ; at the end of five months he was made to try to walk, but the leg swelled, the fistulæ reopened, and at last amputation became necessary, fifteen months after the fracture. Dissection showed the astragalus and tibia soldered together by their articular surfaces, by a white and fibrous tissue, allowing, however, of a very slight motion; so also were the astragalus and os calcis; in both joints the cartilages were thinned in some places, and in some places entirely gone.

The fifth and last case is much more remarkable. A young man of twenty-seven, affected with oblique fracture at about the middle of the femur, was treated by permanent extension for the space of twenty-two months; no callus was formed, and he therefore submitted to amputation. The knee was swollen and stiff, and entirely incapable of flexion. The cartilage of the inner condyle of the femur and that of the corresponding surface of the tibia were found eroded to the extent of a franc-piece, a thin false membrane being interposed between them and extending to some distance over the rest of the cartilage. The external surfaces were joined by a strongly adherent false membrane; moreover, at the point of greatest convexity of the femoral condyle, the cartilages of the two bones were entirely blended for a space of eight or ten millimètres, so that no trace of demarcation could be found between them; they were not worn away at all, the single resulting cartilage having just the thickness of the two when isolated. A similar fusion had taken place between the patella and femur. In the tibio-tarsal articulation, there were found effusion of blood, very thick and adherent false membranes, and thinning and erosion of the cartilages. So also in the metatarso-cuboid, and in the phalangeal articulations. The bones, though softened and infiltrated with blood in their spongy

portions, did not present, says the author, the appearance of inflammation.

These facts are certainly very remarkable, and however they may be interpreted, they warrant important practical inferences; but since we are now concerned only in discussing the theory, do they entirely prove that mere want of motion can suffice to induce such unpleasant results? I answer without hesitation, no. I have given in my *Anatomie Chirurgicale*, the observations of MM. Cruveilhier and Kuhnholtz, according to which entire immobility of the lower jaw for periods of sixty to eighty-three years had not led to fusion of the temporo-maxillary articulation. M. Teissier mentions these two cases, and justly adds, that fibrous anchylosis is much more rare after fracture of the upper than of the lower extremity. But he does not give the true explanation of this; he looks for it in age, constitution, confinement to bed, etc., forgetting that in his own patients the hip-joint was exempt from the affections which involved the rest. Elsewhere, however, he is struck with this circumstance, and explains it by the difficulty of keeping this joint at rest. But I have recently examined a person who died more than ten months after the commencement of a psoas abscess which had kept the thigh immovably flexed, and found not the least trace of alteration in the joint.

This one word, flexion, seems to me to give the key to the problem. The joints of the upper extremity are less liable to anchylosis, because they are more readily kept flexed. Extend the carpal or the phalangeal articulations, and you cause formidable stiffening. All the patients mentioned by M. Teissier had the knee forcibly extended; and we know well that complete and prolonged extension stretches and fatigues the muscles and ligaments, besides subjecting the articular cartilages to severer pressure than any other position. Shall we blame only this continued pressure? It suffices to explain the erosion, but for the formation of false membranes I consider adhesive inflammation as requisite. But, says M. Teissier, the patients never complained of pain in the joints! Pain certainly is not an inevitable accompaniment of inflammation of this kind; and even outside of the joint, is there not evidence enough in the hard and compact engorgement of the cellular tissue, of the synovial sheaths, etc.? Has not M. Teissier twice seen hydarthrosis of the knee, without pain, ensue upon simple fractures of the thigh and leg, treated by extension? Here certainly was inflammation.

Moreover, there are some cases in which the inflammation is undoubted, and manifest to any one. Now has it any other effect than that of causing effusions of serum, sometimes bloody, injection and destruction of cartilages, formations of false membrane, and engorgements of the surrounding tissues? Pain would then be the sole symptom distinguishing the one condition from the other; but I have twice found thick and red false membranes in the hip-joint,

after intra-capsular fractures of the cervix femoris; and as these formations could not be ascribed to want of motion, inflammation is the only available theory of their production; yet in these two cases the patients had complained of no more pain than had others whose joints I found perfectly healthy.

I think then that the adhesive inflammation plays a much greater part in the production of fibrous anchylosis than was supposed by M. Teissier; but this question is practically of only secondary moment. The really important conclusion to which this inquiry leads is that want of motion does not induce anchylosis, unless conjoined with extension of the limb.

But aside from this disastrous termination, there very often remains, as has been said, a stiffening of the neighboring joints, the cause of which should be sought out. M. Teissier regards it as purely muscular; but this cannot be admitted. When we endeavor to give motion to these joints, it is not the muscles, but the ligaments which offer the principal resistance; if a slight movement is forcibly made, pain is induced in the ligaments themselves, and swelling occurs around the joints; the symptoms brought on are exactly similar to those of a sprain, and have a like origin,—the stretching of the ligaments. How is it now that the ligaments should be stretched by movements not exceeding or even equalling their natural extent? What meaning is to be attached to the words *stiffening* and *contraction*, as employed by surgeons?

It is very true that the ligaments, merely from being long kept at rest, tend to shorten, and that to a very notable degree. I have dissected fingers, long stiffened in a flexed position, and have more than once found the cartilages and synovial membrane sound, and the muscles free; the ligaments alone prevented extension; and if a sufficient force were exerted to obtain this, those fibres of the lateral ligaments closest to the surface of flexure were seen to stretch even to breaking. The tendons themselves become shortened; thus for instance the ligamentum patellæ, which is really but the continuation of the tendon of the quadriceps, sometimes loses half its original length, drawing down the lower fragment and twisting it in the most singular manner. (See *Fig.* 81.)

All positions of the limb are more or less conducive to contraction of the ligaments. In forced extension, it is those of the surface of extension which are relaxed, and hence which shorten most; thus the knee, long kept straight, hardly ever recovers to the full its power of flexion. Forced flexion acts on the opposite ligaments; for instance the arm, long confined to the trunk, loses something of the motion of elevation toward the head. Semi-flexion shortens especially the lateral ligaments, hindering at the same time the extremes both of stretching and of bending, as is particularly observable in the elbow; so that the surgeon, surrounded by shoals, seems

to steer clear of one only to strike upon another. Let this idea then be borne in mind, as important to the successful treatment of fractures; that position, whatever it be, is injurious only when combined with a too prolonged want of motion; and that the limb should not be retained in this dangerous immobility for a longer time than is absolutely necessary.

I shall not dwell upon retractions of the muscles themselves; these belong as much to the history of organic affections of the joints as to the subject of fractures. I shall only add that they are nearly always associated with some degree of paralysis of the affected muscles and of their antagonists, and thus is explained in great measure the weakness of limbs in which the work of consolidation has been slow.

§ V.—*Of Non-union, or False Joint after Fracture.*

Want of bony union, one of the most troublesome terminations of fractures, is happily also one of the rarest. It need hardly be said that reference is had here not to intra-articular fractures, in which union by fibrous tissue is almost the rule, but merely to fractures in the continuity of the bones, and chiefly in the long bones of the extremities. No reliable statistics have as yet shown us the degree of frequency of this annoying termination. Walker, of Oxford, affirms that it occurred in only six or eight out of a thousand cases treated by him. Sir Stephen L. Hammick, of the Hospital at Plymouth, counted only three cases of this kind; Liston says he had but one; Pierson likewise mentions but one in a total of 367. At the Pennsylvania Hospital, among 946 fractures admitted from 1830 to 1840, union failed to take place in but one; while thirteen cases of false joint presented themselves there from without, in the same space of time.* Lastly, according to Lonsdale, of nearly 4000 fractures observed during ten years at the Middlesex Hospital, there were scarcely five or six cases of non-union.

As for myself, I have not as yet seen union fail in any case of fracture treated under my direction, and have had occasion elsewhere to observe only eleven instances. This cannot be compared with the experience of Amesbury, in London, who stated, in 1829, that he had seen already fifty-six cases, and two years afterwards that the number had increased to ninety.

We know somewhat more nearly in what proportion false joint occurs in the different bones of the skeleton. Norris has drawn up a table comprising 150 cases, among which may be counted:

* Norris, *On the Occurrence of Non-union after Fractures; American Journal of the Medical Sciences*, Jan., 1842.

In the humerus	48
" femur	48
" leg	33
" forearm	19
" jaw	2

My eleven cases offer rather more variety. Four were in the humerus, two in the forearm, one in the femur, one in the leg, two in the clavicle; lastly, one was in a rib.

M. Guérétin is preoccupied with another idea; and starting from this physiological law established by M. A. Bérard, "*Of the two extremities of a long bone, it is always the one toward which the nutritious foramen is directed which earliest unites with the shaft of the bone,*" he inquires if this greater rapidity of the physiological process affects also the reunion of separated epiphyses, or that of fractures; and if consequently bony union is not oftener wanting in fractures situated toward the end away from which the nutritious vessel is directed. The facts collected by him would seem actually to solve the question in the way presupposed from the theory; to speak only of false joints,

Of nine cases involving the humerus, five were in the upper half, and only four in the lower, toward which the nutritious foramen is directed.

Of eight cases in the forearm, one alone was at the upper part, in the course of the artery; seven in the lower.

So also for the thigh and leg, making in a total of thirty-five only ten, or less than a third, occurring in the part of the bone traversed by the artery, and twenty-five in the other portion.* Other researches, made in England, give no slight support to this doctrine; Curling has announced that those fragments of long bones, from which the artery is cut off by reason of a fracture, undergo a sort of atrophy, presenting a larger medullary canal, with thinner walls, and a spongy tissue less dense. But on the one hand, the facts given by Curling are very rare exceptions; I have not seen one such instance in the public museums of Paris; and on the other hand, Norris has arrived at conclusions so different from those of M. Guérétin, that in a total of forty-one pseudarthroses, whose seats were clearly made out, twenty-seven were in the direction of the nutritious arteries, and only fourteen in the other portion of the bones. Adding together the two tables, we have seventy-six cases in all, of which thirty-seven occupied one part, and thirty-nine the other part, of the bones; the division could hardly be more equal.

The male sex would seem singularly predisposed to pseudarthrosis, compared with the other. In Norris's table, the sex is indicated in 147 cases, among which we find but eighteen women. My own ob-

* See M. Guérétin's Memoir in *La Presse Médicale*, p. 45.

servations have all concerned men, except a false joint in the humerus of a little girl of three years.

The question of age has here some interest, since on theoretical grounds it has been stated that consolidation is more difficult in old people. I have therefore made a careful abstract of 104 cases, knowing the precise date of each fracture; and I have found the proportion to be as follows:

Below 5 years	1
From 5 to 10 years	2
" 10 to 15 "	3
" 15 to 20 "	4
" 20 to 30 "	50
" 30 to 40 "	19
" 40 to 50 "	14
" 50 to 60 "	6
" 60 to 70 "	3
Over 70 years	2

Whence it follows, in spite of common opinion, that old age presents the fewest instances of non-union, and the period from twenty to thirty years the greatest number.

It has been questioned whether or not different seasons and temperatures could have any influence in this respect; but hitherto the point has not been cleared up by observation.

The effect of diet is less doubtful; Hewson has related the case of a man aged 35, affected with simple fracture of the tibia, who had been from the first subjected to copious bleedings, and deprived for six weeks of animal food, and who at the end of nine years still had a false joint. Noël has seen consolidation retarded for eight months in a girl of eighteen, of good constitution, whose relations had allowed her but six ounces of bread per diem; six weeks of good nourishment sufficed for the formation of a solid callus. Other examples could be cited, but few of them are so remarkable as the two cases of fracture of the humerus, observed by Brodie in a man and woman confined for several months to one sort of diet, in order to lessen their embonpoint; in both, consolidation was wanting. These facts have their value, as showing that we must give nature, in the form of ample nourishment, the power necessary for the restoration of broken bones; still, the danger of the attenuant treatment should not be overrated, when circumstances call for it. Norris reports the case of a young man of nineteen, with fracture of the thigh complicated with delirium, from whom 192 ounces of blood were drawn during the first fifteen days; consolidation was completed in three months.*

* Hewson, *Mémoire sur le Mécanisme des Articulations Artificielles, etc.; Journal du Progrès*, tome ix, p. 161; Noël, *Prix de l'Académie de Chirurgie*, tome v, p. 38; Norris, loc. cit.

Pregnancy has sometimes seemed to hinder consolidation. Fabricius Hildanus first noticed this; in a woman of thirty, seven months gone, whose leg had been broken by the kick of a horse, the fragments remained movable until the twenty-third week, and the callus was not completed until the thirtieth. Another woman, aged 40, was suckling one child and two months gone with another, when she broke her leg. At the fortieth day, no callus forming, Fabricius made her wean the child; but the fracture was unaffected until her delivery, after which it was consolidated in forty days. Hertodius, Alanson, Bard of New York, Condie of Philadelphia, and others, have reported analogous cases; but instances of union during pregnancy are far more numerous; Hertodius has given one, Latta has himself seen four, Léveillé and S. Cooper each one; Liston says he has seen several; and Amesbury, who among ninety cases of false joint saw but two in pregnant women, goes so far as to say that this peculiar condition was in them less accountable for the result than the insufficiency of the apparatus used.

This assertion of Amesbury is too little in accordance with observed facts to merit any belief; but it remains to be explained why, in some cases, pregnancy hinders or retards union. Norris inclines to the idea that it has of itself no direct influence, but that it acts only according to the degree of debility induced by it; in support of which he adduces three cases observed by Sir Stephen L. Hammick.* In the first, a fracture of the leg, occurring in the early months of pregnancy, remained for some time stationary; but the woman was extremely reduced by obstinate irritability of stomach preventing her retaining any aliment; as her condition advanced, the stomach resumed its functions, the patient recovered her strength, and the fracture became united. Another woman, toward the close of her term, had the humerus broken; she was much exhausted; being delivered, she endeavored to suckle the child; the fracture made no progress toward healing; but the child being weaned, her strength returned, and consolidation ensued two months afterwards. Lastly, a third woman, likewise affected with fracture when near her accouchement, had no union; she gave birth to the child, but did not suckle it, and her fracture was soon cured.

These observations have their value; Fabricius noticed that his first patient was small, weak and emaciated; but the second was fat and plethoric. Does obesity exert the same influence as leanness? Apart from pregnancy, we see persons both very fat and very thin, in whom fractures are united without difficulty.

In some of the above-mentioned cases, it seems that lactation also

* [*Practical Remarks on Fractures, etc., by Stephen L. Hammick*, London, 1830.]

acted unfavorably upon the healing of fractures; and several authors have not hesitated to count this among the causes of non-union.

We must, however, correct here an error in words; the different physiological conditions enumerated too often fail in the effect attributed to them to merit the name of causes, and can at most rank merely as predispositions.

Among the general causes of non-union are likewise placed the diatheses or cachexies which we have already noticed in treating of the etiology of fractures,—scurvy, gout, cancer, syphilis, scrofula and rachitis. We exclude at once gout and scrofula, the influence of which is as little proved in one case as in the other. We have elsewhere sufficiently shown under what circumstances cancer hinders consolidation. Rachitis, except perhaps in cases of extreme wasting, seems rather to hasten union than to interfere with it. It remains for us to say a few words concerning the influence, in this respect, of scurvy and of syphilis.

Scurvy appears incontestably to affect the formation of callus. Thus the Journal of Desault gives the history of an oblique fracture of the femur, complicated with a scorbutic tendency, in which the callus was not thrown out till the seventy-seventh day. In another subject, a like disposition retarded the union till the one hundred and fourth day. I have myself seen, at Bicêtre, an extra-capsular fracture of the cervix femoris in a scorbutic old man, which at the ninety-fifth day showed no sign of reunion; he died, and I ascertained at the autopsy that there was not even a fibrous callus; the fracture, but for some wearing away of the fragments, resembled a quite recent one. (See *Fig.* 68.)

The action of syphilis is more obscure. Sanson has seen two fractures refuse to unite, one for eight and the other for eighteen months, from its influence; under anti-syphilitic treatment they were cured. Nicod, Beulac, and Condie, have seen like cases. But these are very rare exceptions; we have already quoted from Marcus Donatus the case of a Portuguese in whom two successive fractures, attributed to constitutional syphilis, were readily healed. M. Lagneau has seen numerous instances of consolidation in analogous cases; Oppenheim also has observed such.*

Lastly, violent fevers, smallpox, typhus, visceral inflammations, generally retard the process of healing; I have dissected a fracture of the thigh at the thirty-fourth day, in a man who had been in a persistent febrile state from the time of injury, dying at last from metastatic abscesses; the broken ends were surrounded by clots of blood, and union was hardly begun.

The local causes of non-union are much more numerous; they may

* See A. Bérard, *Des Causes qui Empêchent ou Retardent la Consolidation, Thèse de Concours*, 1833; Norris, loc. cit.

be classed under three heads, according as they affect the limb apart from the fracture, of which they are complications more or less direct; or concern the fracture itself and the state of the fragments; or lastly, are due to negligence or to some fault in the treatment.

To the first class belong (1) *paralysis;* (2) *obstacles to the circulation;* (3) *acute inflammations*, such as erysipelas and phlegmonous abscess.

(1.) *Paralysis* certainly has an influence which should be taken into account. In a case reported by Travers, there was at once fracture of the humerus, of the lumbar vertebræ, with paraplegia, and of the leg; the first was united in the usual time, the last not at all. Tuson has seen non-union in the fibula from a similar paralysis; and B. Phillips ascertained at the end of five weeks, in an analogous case which terminated fatally, that the work of reparation had not even been begun. It must not however be supposed that there are no exceptions to this rule; Busk published in the London Medical Gazette, in 1840, the history of a man sixty-five years old, paraplegic for twenty years, entirely deprived of both motion and sensibility in his lower extremities, who nevertheless, having broken his left leg, had it entirely united at the end of five weeks.

(2.) *Ligature of arteries*, above the fracture; has this really the effect of hindering the formation of callus? Dupuytren thought it had. In a woman aged 62, whose femoral artery he had tied for traumatic aneurism complicated with fracture of the leg, the callus was hardly begun at the close of a month; it had but little firmness at the end of the second month, and did not seem quite solid till after the fourth. But on the other hand, Delpech, having had a similar case in a man of thirty years, saw the callus completed much sooner; the patient walked without crutches at the ninety-second day. And lastly B. Cooper, having tied the crural artery in a case of fractured femur with injury to the popliteal, observed the fracture no less firmly united in six weeks.*

(3.) *Erysipelas*, or *phlegmonous abscess*, occurring in a fractured limb, will generally retard the solidification of the callus. When a pupil at Val-de-Grâce, I saw, in M. Fleury's ward, a man who had fractured one of the phalanges while drunk; there ensued what were then called symptoms of gastritis, which required treatment; after this, phlegmonous inflammation declared itself in the vicinity of the fracture; the callus did not begin to form till this had subsided, and the bone was not firm till the man had been two months and a half in the hospital.

[Erysipelas being universally recognised as an asthenic disease, in the fullest sense of the term, in all its conditions, may it not be to

* Dupuytren, *Des Anévrysmes qui Compliquent les Fractures; Leçons Orales*, second edition, tome ii, p. 507; Norris, loc. cit.

the state of system, of which this is a very plain index, that we must refer the want of union in the bone? In other words, are not the erysipelas and the non-union results about equally close of a common cause? And yet a case is quoted from Seerig, by Dr. Norris, in which erysipelas seemed to act like a blister in hastening consolidation. Kirkbride gives a similar case in the *American Journ. of Med. Sciences*, 1835.]

Among the causes of non-union connected with the disposition of the fragments, have been placed (1) *the obliquity of the fracture;* (2) *the separation of the fragments;* (3) *interposition of bodies between the broken ends;* (4) *suppuration*, in compound fractures; (5) *want of nutrition in one of the fragments;* (6) and lastly, *some affection of the bone*, just at the level of the fracture.

(1.) Dupuytren especially has attempted to place in relief, as a cause of non-union, the *obliquity of the fracture.* While in transverse fractures, said he, the callus is solid enough at the end of forty days, because the fragments mutually support one another against the action of the muscles, in oblique fractures, on the contrary, the fragments only touch by inclined planes, and afford one another no purchase; whence the action of the muscles comes entirely on the provisional callus, which, being weak, yields, permitting displacement and overlapping of the broken ends; from which arise pain, shortening, deformity, and the false joints so common after fractures of this kind. And consequently, Dupuytren would have the treatment of oblique fractures continued twice as long as that of transverse, fixing its average duration at three months.*

In support of Dupuytren's ideas, M. A. Bérard has added that *the pseudo-articular surfaces were oblique in nearly all the patients in whom surgeons have attempted a cure.* I have not seen that this obliquity was nearly so common, and the statement is certainly exaggerated. But every surgeon must have been struck with the relative slowness of consolidation in oblique fractures as compared with those which are serrated or transverse. Must we then accept Dupuytren's theory, and the yielding character of the provisional callus? We know already what we hold as to the callus; and touching the question now under discussion, I believe that what most retards the union of oblique fractures is the bad arrangement of apparatus, permitting the fragments not only to overlap, but even to leave one another; so that the lymph effused in the interspace is too abundant, and the membranous tissue too lax to readily become the seat of calcareous deposit. Sir A. Cooper taught that, to obtain rapid consolidation, a certain degree of pressing together of the fragments was necessary. "We see," said he, "that if the ends of the bones are separated from each other by muscular action, as occurs sometimes

* Dupuytren, *Leçons Orales*, second edition, tome i, p. 37.

in fractures of the femur, tibia, humerus, ulna, and radius, union does not occur; till the surgeon, by means of a strong leather band buckled round the limb, forces the fragments together, thus producing the inflammation requisite to the production of bony callus."* I agree entirely in this opinion, and in speaking of fractures of the leg shall cite cases of consolidation obtained in less than six weeks by my screw-apparatus, which exerts the greatest possible pressure on the fractured surfaces.

(2.) This first alleged cause of non-union blends itself somewhat with the second, viz., the *separation of the fragments.* Transverse fractures of the patella are the most common examples of the effects of this separation; here fibrous union is the rule, and bony consolidation a very rare exception. Such is the case also in fractures of the long bones of the extremities. Sir A. Cooper has related three cases of fracture, with loss of substance, of the tibia, the fibula retaining its length; between the separated fragments no bony formation occurred. Experiments with similar fractures, in animals, have given like results. This law, however, has many exceptions, if one may believe observers. Delamotte says that he extracted a portion of the tibia four fingers'-breadths long, at about the sixtieth day of a fracture of the leg, and that the formation of callus took place perfectly. The period of extraction in this case favors the idea that the reparation occurred by means of the periosteum, as in any case of necrosis; but in the next observation, the same surgeon relates the history of a recent fracture, in which he removed a portion of the cylinder of the tibia five or six inches long, which was replaced, without shortening, by solid callus. Gooch says he removed five inches of the tibia, Phillips likewise five inches, with equally satisfactory results.† Without at all questioning the good faith of these surgeons, we may believe that they were deceived, mistaking for bony callus a cicatrix of quite another character; and nothing short of careful dissection could demonstrate the reality of such wonders. Norris has treated a child twelve years old, from whom he removed two inches of the tibia; the callus formed, but with half an inch shortening. This is somewhat more probable; yet there is still some room for doubt. It is actually true that there are in our museums several specimens of fragments separated one or two centimètres, which have still been united by solid callus; but we see that the wonder lessens as we view it more closely; and these results may be considered even as ordinary facts.

(3.) *The interposition of a foreign body* between the broken ends is much more rare. Sometimes the substance comes from without; thus M. A. Bérard quotes from Rossi a case in which a ball, lodged

* See Sir A. Cooper's article on *intra-capsular fractures of the cervix femoris.*

† Delamotte, *Traité compl. de chirurgie*, obs. 79 and 80; Norris, loc. cit.

in the medullary canal of the humerus, hindered the union of the fracture; and under such circumstances, it would doubtless be somewhat absurd to count on the efforts of nature. These have, however, sometimes done a great deal; M. Vogelvanger treated, and cured in sixty-four days, a compound fracture of the femur; the patient dying at the end of two years, the autopsy revealed within the mass of callus a bit of iron about two inches and a half in length, about half of which projected outside of the bone.* I have already spoken of the jaw broken by a gunshot injury, the callus of which had numerous grains of shot imbedded in it (see *Fig.* 16;) and I have among my drawings one of a femur fractured by a ball, during the three days of July, 1830; the ball lodged between the fragments, as is shown by the empty space separating them, while posteriorly they are united by a pretty firm callus; the specimen is in the museum at Val-de-Grâce.

But most commonly it is by splinters, by muscle, or by effused blood that the formation of callus is hindered. Splinters, in a simple fracture, are easily enough surrounded by the callus; but in gunshot fractures, the importance of extracting them is well known to military surgeons. The interposition of some portion of muscle or of aponeurosis has been alleged as a cause of non-union, mainly from a case reported by Samuel Cooper. It was that of a woman who had a fracture of the humerus several months old, but still ununited, when she died of some other affection; the lower fragment, sharply pointed, was imbedded in the substance of the biceps muscle, so that it could not possibly be disengaged. Dupuytren likewise ascertained, by the dissection of a non-consolidated fracture, that the callus was hindered from forming by the interposition of muscular fibres. These are, however, very rare cases, and the chasm must be very considerable to prevent the callus from filling it up. M. A. Bérard relates a curious case, which has been communicated to the Anatomical Society, and which may serve as a counterpoise to those of S. Cooper and Dupuytren. In a clavicle which had sustained a fracture long before, the two fragments were seen separated to the distance of an inch by the sub-clavius muscle, but united by two bony bridges, between which the muscle, itself ossified, was confined.

An excessive effusion of blood may also hinder the formation of callus; but care must be taken not to mistake one cause for another. In the third observation of Dupuytren's Memoir on Aneurisms, already cited, the effusion was so considerable that amputation of the thigh was deemed necessary; the fracture dated back less than forty days, and was already solidified; but the patient had been almost without fever. In the fourth observation, the patient had had constant fever; the callus did not become solid for more than two

* *Gazette Médicale*, 1838, p. 445

months. I have before quoted an observation of my own, of a case in which the non-union might have been attributed to the numerous clots around the fracture, had not the fever and the metastatic abscesses which carried the patient off exerted a less contestable and less contested influence.

(4.) *Suppuration, in Compound Fractures.*—Every one knows that a fracture with suppuration takes more time to heal than one buried among the muscles. The larger and more contused the wound, the more abundant the suppuration, and the less ready the formation of the callus. Gunshot fractures are the slowest of all in uniting; and next to them come divisions of the bones by cutting instruments; which facts may be attributed, mainly at least, to the abundant suppuration which ensues in both.

Besides suppuration occurring just at the seat of fracture, a simple external wound, an ulcer, seems also to weaken, lessen, or interfere with the work of consolidation. Duhamel ascertained that in a young pigeon with a wounded wing the callus at the fifteenth day was no more advanced than at the tenth in a sound bird.

(5.) *Defective nutrition* of one of the fragments can hardly be alleged except in the case of intra-capsular fractures of the femur and of the humerus, of splinters almost entirely stripped of periosteum, or lastly, when the limb is so nearly cut off that the circulation only goes on through a very narrow flap of tissue. We need not dwell on this very evident cause of non-union, which defies all treatment.

(6.) Nor shall we discuss at any length *diseases* of the fractured bone. Of course caries, necrosis, or cancer will constitute an obstacle to consolidation. Hydatids developed in the medullary canal had this effect in cases mentioned by Webster, Wickham, and Dupuytren. A distinction must however be drawn in regard to exostoses. Arnott resorted to amputation in a fracture of the tibia seated at an exostosis, which was not united at the end of a whole year; but Brodie, having to treat a fractured clavicle under analogous conditions, saw the callus form as readily as usual.* We see, then, that the complication of exostosis need not destroy all hope, and that we must be guarded in our prognosis in such cases.

If, therefore, among all these causes there are some which cannot be entirely avoided, some of them may be advantageously combated, while if allowed to act they would render the surgeon liable to the charge of negligence or of error.

But those which we have still to study are of a different nature, in that the treatment itself gives rise to them in fractures which have the best disposition to unite. Such are (1) *the abuse of wet dressings;* (2) *the too early application of bandages;* (3) *excessively tight bandages;* (4) *the too prolonged application of bandages;* (5) *local*

* Norris, loc. cit.

scurvy; (6) *motion of the fragments;* (7) *the premature use of the limb.*

(1.) It is not only in our own times that the *abuse of wet dressings* in the treatment of fractures has been denounced as injurious; Paulus Egineta complained of the improper employment of fomentations; Avicenna denounced affusions of oil and of hot water during the organisation of the callus, *because they hinder reparation;* Amesbury says the same of cold lotions; and M. J. Cloquet, among the principal causes of local scurvy, speaks of the too prolonged use of emollients.

On the introduction of continued irrigation as a form of wet dressing, great hopes were at first excited, particularly in reference to compound fractures. But besides other serious dangers, these irrigations generally retard consolidation; thus of nine compound fractures, the history of which is given by M. Nivet, two only were united within the usual time; two required two and a half or three and a half months; two, five and seven months; one was dismissed without union at the one hundred and ninetieth day; and the remaining two died.*

(2.) The *premature application of bandages* has excited especial attention since the general introduction of the immovable apparatus. M. Rognetta, having thus treated a fracture of the leg and a fracture of the thigh in M. Bresalet's ward, had the annoyance of seeing them still un-united at the end of three and a half months. MM. Nanula and Pétrunti, being consulted, attributed this want of success partly to the following novel cause. "We may affirm," said they, "from our experience, that fractures to which the apparatus is applied during the first period unite more slowly than such as are at first left free, being confined only during the process of consolidation."† The apparatus acted then, according to them, by exercising too strong a compression, and thus preventing the inflammation necessary to solid union. In this point of view a bandage too early applied would act just like one applied too tightly; whence, for the sake of a clear discussion, we must study the effects of such constriction.

(3.) The *too great pressure of bandages* is one of the causes of non-union most insisted on by A. Paré; and after him, Wiseman in the seventeenth century, and Duverney in the eighteenth, agree in saying that nothing hinders so much the formation of callus. This is confirmed by experiment; thus, Delahaye having broken the leg of a young pigeon, and then compressed the limb tightly between

* Malgaigne, *De l'irrigation dans les Maladies Chirurgicales.* See also M. Nivet's memoir in the *Gazette Médicale,* 1838, p. 36.

† Rognetta, *Résultats des expériences faites à l'Hôtel-Dieu,* etc., *Gaz. Médicale,* 1834, p. 257; Nanula and Pétrunti, *Réponse à M. Rognetta,* ib. p. 630.

two hollow splints, Duhamel, who assisted at the dissection, tells us that at the eighth day there was neither swelling of the periosteum nor any disposition toward uniting. Troja obtained the same result in dogs, making pressure by means of bandages. Now when we examine the first instances of non-union under the treatment by the immovable apparatus, we find that besides its too early application, its excessive tightness is mentioned, and I incline to the opinion that this latter is the fault. It may be answered that this compression can hardly be exerted on bones surrounded, like the femur, by a mass of muscle; that it is nothing at all in many cases where the limb emaciates so as to leave a space between it and the bandage; that many false joints are cured by this very means, etc. No reply need be made to such objections, which mere theory furnishes against every opinion; and for my own part, I consider that pressure is injurious in the early stage of a fracture, by hindering the swelling of the periosteum and preventing the access of blood to the affected part. But it must be confessed, I have several times applied the dextrine bandage when the callus was already developed, carefully avoiding excessive tightness; and yet I have several times found consolidation imperfect at the end of the usual time for its occurrence, though it afterwards did take place. We must therefore seek some other cause.

(4.) *Too prolonged application of the bandage*, although less generally recognised, exerts no less an influence than too great tightness. M. J. Cloquet is perhaps the only author who has given it a few words in passing. "The fractured limb," says he, "inclosed in an apparatus excluding air and light, is affected with a sort of chlorosis; it becomes pale, flaccid, and sometimes slightly œdematous, so that the lymphatic fluids seem to predominate in it. These changes are much more notable in the lower than the upper extremity; being more distant from the centre of the circulation, the former have less energy, and the callus in fractures of their bones is produced more slowly."* If this statement were strikingly true at a time when bandages were not generally put on until after the subsidence of inflammatory symptoms, and were renewed from time to time in the course of the treatment, how much more does it apply at present, when the limb is usually enveloped in an immovable apparatus from the first to the last day! There is no surgeon who, examining a broken leg at the thirty-fifth to the fortieth day, and finding the fragments still movable, has not been struck with the wasted flesh, and the scaly and dead appearance of the epidermis; while toward the heel, the skin, puffed with œdema, is pale and blanched. Consolidation is not therefore yet despaired of, but it requires a long

* J. Cloquet, *Du scorbut qui se manifeste d'une manière locale pendant le traitement des fractures, Archiv. de Médecine*, tome i, p. 470.

time for its accomplishment; and why resort to causes often merely imaginary, when atony of the limb is present?

(5.) Now if to this powerful cause are joined others; if we have to treat subjects enfeebled by age, previous disease, loss of blood, or insufficient diet; when the air is cold and insalubrious, as in autumn or in a rainy winter, and especially if the use of emollients is continued till the bandages exhale a mouldy smell, then the affection becomes more serious, and we see coming on all the symptoms of what is called by M. J. Cloquet *local scurvy*. We shall not attempt to improve upon the description, given as follows by his masterhand.

"The limb seems to lose its temperature, the skin assumes a dull, pale white color, swells, and softens. The epidermis rises and peels off; sometimes it forms phlyctenæ, full of a puriform or slightly viscid liquid; the true skin below seems moist and swollen; the hairs fall off or come away with the epidermis, as happens in the skins of animals when they are macerated. If the fracture is attended with a wound, the granulations swell, become softish, dark-red, discharging only an ichorous pus, and bleeding at the slightest touch. Soon the limb is covered with ecchymoses, which seem usually to begin about those hair-bulbs which still retain their place; these ecchymoses spread more and more, sometimes becoming very large. The process of consolidation is arrested; the fragments still present some mobility when their union should be complete. Sometimes a bloody exudation occurs at several points of the softened skin. While these local symptoms are manifested, the general condition of system seems in many cases unaffected; the gums are firm, not swollen or bleeding; the appetite remains good, digestion goes on well, the sleep is undisturbed, and the mind cheerful, except that the patients are wearied by the long duration of the treatment, and chagrined that their fractures do not become united."

M. J. Cloquet has twice had an opportunity of ascertaining by dissection the state of the affected parts. The first time, the subject was a robust street-porter, fifty-five years of age, suddenly carried off by an attack of ileus, after having been seven months under treatment for a fracture of the right leg. The local scurvy had shown itself at about the second month, developing itself more and more; still, the rest of the economy was unaffected, and two days before his death, his general health was in a satisfactory state. At the autopsy, the skin covering the limb, besides being almost entirely deprived of hair and of epidermis, seemed soft, easily torn, and covered with very numerous blackish and violaceous ecchymoses; similar ecchymoses were seen in the subcutaneous and intermuscular areolar tissue; the muscles were pale, flaccid, softened, gelatinous, and displayed here and there in their substance considerable effusions of dark fluid blood; the bones at the seat of fracture showed no trace of consolidation or

of tumefaction; only the compact tissue seemed to have become somewhat spongy, and infiltrated largely with black and viscid blood. The periosteum above and below the fracture was detached and raised up by the same liquid, which also formed ecchymoses within the medullary tissue; the latter was gelatinous, reddish, and nearly liquefied. Other ecchymoses infiltrated the ligaments about the knee and foot, and the soft parts about the lower end of the thigh; higher up, the skin, muscles, and other organs, presented no such appearances. Similar lesions were observed in a woman forty years old, of feeble constitution, who died eight days after the supervention of typhoid fever, having been six months under treatment for fracture of the right leg. In her, consolidation had apparently begun toward the second month; but fifteen or twenty days later there was the most perfect mobility of the fragments, and symptoms of local scurvy were evident in the affected limb.

I believe we must distinguish in this affection two quite distinct degrees; one very common, for the production of which a too prolonged application of the bandages will suffice, and which is characterised by detachment of the epidermis, œdema, and paleness of the skin, sometimes with the formation of phlyctenæ; the other much rarer, requiring the conjunction of other unfavorable conditions, and manifesting itself by ecchymoses. When thus advanced, the scurvy can hardly remain a merely local disorder, but tends to become constitutional, as seen by M. J. Cloquet in several of his patients.

(6.) *Movements of the fragments*, whether due to the patient's restlessness, to some defect in the apparatus used, or to any other cause, is the obstacle which most directly interferes with union. This fact has never been contradicted, and its mere enunciation will in great measure suffice; it may however be added that the majority of pseudarthroses occur in the humerus and femur, the two bones least readily subjected to restraint; and that of forty-four cases in which the causes of the condition were investigated, Norris found that movement of the broken ends was clearly made out in twenty-two cases, and strongly suspected in several others.

(7.) Lastly, *the premature use of the limb*, directly causing motion of the fragments, acts in the same way; and it is chiefly in oblique fractures, or in those attended with notable overlapping, that surgeons make this mistake. Nothing is more common than to see an oblique fracture of the leg, apparently firm, give way under the patient's weight, and overlap or bend, as the result of premature movement.

Such are the conditions hitherto recognised as predisposing or determining causes of the non-union of fractures. As several of them have long remained obscure, it explains how the writers best entitled to authority on this subject, MM. A. Bérard and Norris, still admit the occurrence of cases in which false joints are produced without any appreciable cause, and which must be referred to idiosyncrasy. The

more I examine this question, the less am I inclined to adopt this idea. Divisions of the soft parts cicatrise with more or less facility in different individuals; but there has never been seen one which obstinately refused to heal merely because of an idiosyncrasy, and there is no reason why the bones should be exempt from a law common to all the other tissues. I have read accounts of pseudarthroses occurring, it is said, in young, healthy subjects, submitted to treatment undoubtedly irreproachable; this last point, the one whose demonstration is most necessary, is one of those which are least positively proved. And is it not a subject calling for reflection, this preference of pseudarthrosis for attacking the youngest and heartiest male subjects? Amesbury was likewise struck with this; of ninety cases of non-union which he had seen, but three were of decidedly bad constitution; another had been exhausted by cholera during the early period of the fracture; add to this number two pregnant women, and the remaining eighty-four all enjoyed sound and robust constitutions. He considers that in these latter the cause of the non-union was purely local, and that in nearly all, the incomplete apposition and the mobility of the fragments were to blame. The merely local causes are, as we have seen, much more numerous; but I firmly believe that when union is deficient, it is generally the treatment that is in fault.

This etiology would not however be complete, were we to pass over one of the most curious phenomena of this whole subject, called by some the *absorption*, by others the *softening* [*ramollissement*] of the callus. The first instances of this were observed in scorbutic patients. Mead relates the case of a sailor who, having broken his clavicle, was sufficiently cured by the end of one month to use his arm just as before the injury; but three months later, in hanging by his arm, the fragment separated, and *the callus became just as at the first.* At the same time, scorbutic symptoms appeared, delaying any effort at consolidation; and it was not till the end of six months, and after the cure of the scurvy, that the callus again became firm. A nearly similar case is mentioned in Lord Anson's Voyages, and Dr. Budd has seen a third.

After scurvy come severe fevers. Lemaire saw, in 1700, at the military hospital in Strasbourg, a soldier who had had a fracture of the tibia thoroughly united, and in whom, eight months afterwards, the callus gradually disappeared during an attack of fever, to form again after his recovery. A. Bonn likewise saw, in an old man, a nearly completed callus disappear during a fever with inflammation and gangrene, which proved fatal. In another observation published by Mantell, a violent fever destroyed the callus of a fracture of the leg, several weeks after its complete formation, in a young man of seventeen; the fever being cured, the callus was thrown out anew, but the limb was much deformed. Hitherto there has been room for doubt whether the bony callus was merely reduced again to a fibrous

condition, or disappeared entirely; but an observation of Schilling's shows that the word *ramollissement* is not applicable, at least in all cases. A man had a fracture of the femur, which was so well consolidated that he could bear some weight on the limb. He had an attack of abdominal typhus; at the tenth day of the disease, all traces of the callus had disappeared; and death ensuing six days after, the autopsy showed the fragments bleeding as in a recent fracture, and enveloped in a sort of membranous sac containing a little dark liquid blood.*

Erysipelas seems sometimes to have the same effect. I published, in 1830, in the *Lancette française*, the history of a fracture of the leg, consolidated at the fifty-ninth day; a month later, erysipelas attacked the whole leg and destroyed the callus, a new formation of which required two months. This circumstance struck me forcibly, and led me to look up similar instances; and I established it as an almost invariable law, that *erysipelas occurring in a broken limb not only retards consolidation, but causes it to go back.* I have, indeed, seen a statement by S. Cooper that Langenbeck saw the same thing in several patients; Dupuytren gives a case; Wardrop two; Wright another; and since then others have been reported.† But it should be stated that it is not always so; when the callus is of old standing, it resists wonderfully. A man aged 47 was admitted into my wards for a fracture of the leg, badly consolidated, and followed by stiffness of the joints. He was attacked by very severe erysipelas, involving the whole limb, and lasting seven days; the callus however lost none of its solidity.

Probably to these causes it will be proper hereafter to add others. Kirkbride has given us an account of a small ulcer, seated just over a recently united fracture of the leg, which became gangrenous, and led to the absorption of the callus.‡ Dr. Penel saw the callus disappear twice successively in the same subject, with no other appreciable symptom than the deposit of a large quantity of phosphate of lime in the urine; the second time nitric acid was given in lemonade, the urine became clear, and the fracture united without any further relapse. Lastly, in Norris's memoir there is recorded a case much more singular, and probably unique. A young man of eighteen broke his humerus at about the middle. Consolidation progressed favorably, until the broken ends were separated by another fall. From that time, not only was there no union, but absorption began

* Reisseissen, *Diss. de Articulationibus Analogis, Præs. J. Salzmann;* Argentor., 1718; A. Bonn, *Thesaur. ossium Hov.*, p. 187; Norris, loc. cit.

† See Malgaigne, *Lancette française*, 1830, p. 217; Dupuytren, *Mém. sur la fract. du péroné*, obs. 4; Wardrop, *Obs. sur l'usage du séton dans les fract. non-consol.; Mélange de chirurgie étrangère*, tome i; Wright, *Réflexions sur la réunion des os fracturés, etc., Journal des Progrès*, tome xv.

‡ *American Journal of the Medical Sciences*, Feb., 1835.

in each fragment, and went on until, without any ulceration or wound, the humerus entirely disappeared; so that, eighteen years afterwards, no trace of it could be detected.*

There being so many obstacles to bony union, the wonder is that false joints are so rare. Many of these causes exhaust their action in retarding consolidation, without absolutely preventing it; it is hard to say, unless five or six months have elapsed since the occurrence of the injury, whether we have to deal with a case of mere slow union, or with one of actual pseudarthrosis. This difficulty is best resolved by dissection.

Norris distinguishes four varieties of false joint:

(1.) The fragments are surrounded by a cartilaginous tumor, in which ossification is not yet begun; there is rather slowness than absence of union, to produce which, rest and compression will generally suffice. An important circumstance in diagnosis is the pain caused by any sudden movement impressed on the limb.

(2.) The fragments are entirely separate, very movable under the skin, and their ends seem to have undergone a sort of atrophy. The limb is much shortened, and hangs useless.

(3.) Union is effected by means of a fibrous tissue of greater or less length, strength, and thickness; sometimes holding the fragments close together, sometimes allowing very free flexion. The fragments are often more or less rounded off by absorption; sometimes again they remain pointed; but the medullary canal is always obliterated at their extremities.

(4.) Lastly, there may be formed a true diarthrosis, constituted by a dense and firm fibrous capsule, smooth internally, and containing a liquid like synovia. The ends of the bone are rounded and polished, sometimes eburnated; and sometimes covered over by cartilages and a synovial membrane.

Of these four varieties, the third is by far the most common. The first should hardly be admitted; the second is quite rare; the fourth perhaps still more so, Boyer and others having actually doubted its reality. The observation published by Duverney and Sylvestre wants exactly those details which are most essential; and it is always hard to judge from a dried specimen whether or not there has been a synovial membrane. But other and better substantiated cases have established beyond a doubt the existence of these accidental diarthroses; A. Key has seen one in the spinous process of a vertebra; Kuhnholtz in the femur; Sir E. Home, Cruveilhier, and Howship in the humerus.† They seem to occur much more frequently in ani-

* Norris, loc. cit.

† See A. Key's observation in Sir A. Cooper's *Treatise on Dislocations and Fractures of the Joints*, art. *Injuries of the Spine*, [p. 386, Am. ed., 1825;] Kuhnholtz, *Considd. sur les fausses articulations; Journ. complém.*, tome iii, p. 289; Sir E. Home, *Transactions of the Society for Improvement of Med. and*

mals than in man; indeed, of nine false joints obtained by M. Breschet in his experiments on dogs, six displayed an articular cavity. I have myself obtained two in an old dog in which I broke the radius and ulna; the capsules were very thick; the ends of the bones were covered with a rough, soft, white layer, like articular cartilage deprived of its polish and made fibrous.

The distinction between purely fibrous union and pseudo-diarthrosis has much more importance anatomically than practically; in the living subject the differential diagnosis is generally impossible. It would be necessary, in order to make a diarthrosis probable, to hear the sound of rubbing of the two articular surfaces against one another; it will easily be understood, moreover, that this diagnosis could be much more clearly made out if the articular cavity should contain thirty or forty floating nodules of cartilages, as in Sir E. Home's patient.

But, I repeat, this has not any great value in a therapeutical point of view, which is the principal one to the surgeon. In practice, pseudarthroses may be divided into three classes, very different from those just described.

(1.) Either the fragments appear absolutely independent of one another, floating, as it were, among the tissues.

(2.) Or, they are joined by the fractured surfaces, without notable overlapping.

(3.) Or, lastly, the overlapping has separated the surfaces, and the fragments touch each other only laterally.

In the two latter cases, there may be again three principal conditions: sometimes the fragments are strongly jammed against one another, so as not even to allow of the introduction of a needle; sometimes they are much looser, and therefore more movable; sometimes, lastly, their extremities are enveloped in "accidental" deposits of bone, evidencing the efforts of nature to bring about union. It is concerning these conditions, rather than the fibrous or diarthrodial structure of the false joint, that we should be informed in order to ascertain the indications in each case.

ARTICLE V.

DIAGNOSIS.

This subject has been to a considerable extent treated of in the study of the varieties of fractures and of their general semeiology; it will therefore suffice to recall here, in a rapid *resumé*, what degree

Surg. Knowledge, London, 1798, p. 235; Howship, *On the Formation of New Joints; Med. Chir. Transactions*, vol. viii, p. 513.

of confidence the surgeon should accord to the different sets of symptoms; but we must also point out some new resources to which we can apply when the ordinary signs are obscure.

The symptoms of fracture are rational or sensible. The rational are, the crack heard by the patient, the pain, the loss of power, the contusion, the primary or secondary swelling; but they can never, even when all present at once, afford ground for a positive diagnosis.

The sensible or physical are, preternatural mobility, deformity, and crepitus. I have nothing more to add to what has been already said concerning the first and last of these; but the different varieties of deformity present several sources of deception against which we must be on our guard. Everything depends on exact measurement, for the avoidance of error; but this measurement comprehends several different processes.

Sometimes it is important to ascertain the increase in thickness of a limb. We may then compare, by means of a graduated tape, the circumference of the sound limb with that of the unsound one, taking care to observe the same level in both, and first of all assuring ourselves that no previous affection has given rise to any inequality in their volume. This mode cannot, however, be adopted in all regions of the body; for instance, in some fractures of the fibula where we would ascertain the separation of the malleoli, it is better to resort to M. Mayor's compasses, which do not indicate the circumference, but only the diameter.

The compasses themselves are insufficient when the bones are completely masked by a considerable swelling of the soft parts. At an early period of the fracture, it is better to wait till the swelling subsides; but the diagnosis often remains still obscure; and the surgeon, uncertain whether he has to deal with a fracture or a luxation, is equally afraid of acting or remaining idle. I then make use, with advantage, of needles inserted as far as to the bones, in each limb, so as to compare the two. Sometimes one needle is sufficient to enable us to judge of the relative depth of the fragments. Sometimes, again, two are necessary, with the compasses applied over them, to judge of the amount of separation of two bones, as at the malleoli. We may make use either of acupuncture needles, of ordinary needles, or of mere pins; they are pushed at once down to the bone, the depth of this beneath the surface is carefully remarked, and they are then withdrawn as quickly as they were entered. Usually not a drop of blood escapes, and I have never seen any bad result, however slight. When pins are used, a simple means of marking the depth to which they have gone consists in nipping them with scissors at the level of the epidermis; we thus make a double notch which can hardly be effaced. Needles passed to and fro over the broken ends may also give useful information as to their position, form, angles, and the presence or absence of splinters; just as sounding makes

known to the mariner the nature, etc. of the bottom over which he sails.

By these means we may with ease and accuracy determine the reality and extent of *transverse* displacement; *angular* displacement sometimes needs a more strict mode of measurement. For this purpose I use a sheet of paper, applying its edge upon the limb so as to represent its vertical axis. At the spot where this axis changes its direction, the paper is so folded, more or less, as exactly to follow it; the salient angle resulting will necessarily show exactly the entering one formed by the fragments. It remains to find the value of this angle; a quadrant would give it accurately, but for greater simplicity we may proceed as follows: a sheet of paper folded in four makes a right angle, or 90°; folding again one of the sides, we have an angle of 45°; adding this angle of 45° to the unchanged right angle, we have one of 135°, and so on. Applying now this extempore quadrant to the already ascertained angle of the fracture, we have, without trouble or loss of time, as close an estimate as possible.

For displacement by *rotation*, we may in the same way extemporise a square; but generally it suffices to compare the two limbs, or to study the relative position of some natural prominences. Thus, the leg being in the horizontal position, the inner edge of the great toe should correspond to that of the patella; if it is turned inward or outward, there is rotary displacement one way or the other.

There remains lastly *overlapping*, sometimes evident at the first glance, but frequently requiring confirmation by measuring the length of the limb. This measurement calls for certain precautions varying with different cases. First of all we must have certain *fixed points*, where we may firmly apply the tape, without danger of moving it to one side or the other. These are usually bony prominences where we press the tape with the nail; thus in the arm, the posterior angle of the acromion, the epicondyle, [the external condyle of English and American anatomists,] the styloid processes; so also in the lower extremity, the iliac spine, the edge of the femoral or tibial condyles, the head of the fibula, the malleoli. For instance, to get the length of the extended thigh and leg, I place one end of the tape on the anterior superior spine of the ilium, fixing it here with the edge of the nail turned upward and pressing against the under face of the spine; and I fasten the other end below the external malleolus by pressing it likewise with the nail. In the arm, I place one nail under the posterior angle of the acromion, the other against the upper edge of the epicondyle.

A second precaution no less important, is to keep the two limbs in the same condition as regards extension, abduction, obliquity, etc. Thus the lower extremities should be kept parallel, as much as possible, and the iliac spines at the same transverse level. For greater accuracy, I have a tape stretched across from one spine to the other,

and fastened by the pressure of an assistant's thumb below each spine; from the middle of this tape—a point in the median line of the body—I let fall another tape perpendicularly, as far as the heels, which are placed at equal distances from it. If by reason of any lesion whatever, one of the limbs is persistently abducted or adducted, and cannot be brought parallel with the other, I place the latter in a corresponding position of abduction or adduction, taking the last-mentioned tape as a guide. Extension or flexion must likewise be exactly the same, as well as rotation; and besides all this, it is important that the measuring tape should not be turned aside by any prominence or swelling which may exist on one side only.

In the upper extremity, the surgeon should follow the same rules, although this seems to be hardly noticed by the majority of observers. I have never seen care taken, in measuring the arm from the acromion, to place the two scapulæ in the same position, the angles of the two acromion processes in the same transverse plane, the two elbows at the same distance from the median line; I myself long neglected these precautions, until at last I learned their necessity. Not only in fractures, but in the diagnosis of luxations and of affections of the joints, does measurement lead us to true or false conclusions according as it is well or badly made. This is too evident to be further insisted on; we shall moreover have to recur to it in speaking of particular fractures.

ARTICLE VI.

PROGNOSIS.

Our prognosis should have reference to several points, viz., the favorable or unfavorable termination of the case; its simple or complicated course; the influence of each complication; the duration of the treatment; and lastly the result as to the functions of the limb.

A simple, recent fracture, the fragments remaining or being replaced in perfect contact, will unite well, without bad symptoms, without deformity, without any detriment to the functions of the limb, in a space of time easily estimated, varying only according to the bone fractured and the age of the patient. Thirty days are required, for instance, for a fracture of the clavicle in an adult or an old man; in a little child, fifteen or twenty will suffice.

But if the fracture has already existed two or three weeks, and still remains as movable as on the first day, the result is more doubtful. It may still unite, especially if the mobility is due to the want of suitable treatment; but the time requisite will be longer; it may not unite at all, and hence our prognosis should be a guarded one.

In a subject affected with any acute disease we are to expect a

slow consolidation, as well as in certain diatheses; and here the inconstancy of the results should make us careful in making statements. So also in a pregnant woman, we should not be too decided; prognosis is essentially the art of foreseeing everything.

If, in a simple fracture, the broken ends remain nearly in apposition, the prognosis is almost as favorable as when they are quite so; only there will remain some little deformity, and a somewhat longer time will be necessary to complete their union.

If the fracture is very oblique, with a tendency to transverse displacement and more or less overlapping, the time required will be at least half as long again as in ordinary cases.

If the fragments overlap so as only to touch laterally, the callus will need twice the usual time to solidify. A simple fracture, with splinters and overlapping, takes still longer, and, besides the shortening, leaves behind it a large and badly-formed callus. If the fracture is double in a single bone, with overlapping of all three fragments, the shortening and deformity are still greater, and the consolidation still slower.

All overlapping tends to cause shortening of the bone; and the cases in which it can be corrected by art are only rare exceptions.

Erysipelas in the limb retards the callus. It may even destroy callus already formed; but this rarely fails to be reproduced subsequently.

Suppuration, even if unconnected with the fracture, retards the callus.

Every fracture with an external wound is serious. The gravity of the case is less in the small bones, greater in the large; it is also modified by the size and character of the wound. There is some reason to fear, if the wound suppurates, that consolidation will be at least much retarded; or purulent deposits may take place in the limb, rendering amputation necessary.

If one of the fragments project out of the wound, the prognosis becomes still more serious.

The more clean and regular a fracture attended with an external wound, the more encouraging is our prognosis. The more it is complicated with splinters and comminuted portions, the greater is the danger. Gunshot-fractures are the most serious of all; in the tibia and femur, they nearly always call for amputation.

There is one exception to the preceding rule: a simple fracture by counter-stroke, when the shock has been violent enough to drive one fragment through the skin, is more apt to be followed by serious and even fatal symptoms than a splintered fracture by direct violence, unless in the latter the soft parts should be excessively torn or contused.

A fracture attended with suppuration requires, *cæteris paribus*, at least thrice the time for consolidation that a simple fracture would;

but this term may be extended from three months to a year, or even more.

In all cases a fracture at the middle of a bone is less dangerous than one toward either extremity; an intra-articular fracture is the worst of all.

Every simple intra-articular fracture tends to unite by fibrous tissue; bony union is the exception.

Every intra-articular fracture with an external wound threatens the joint with true or false anchylosis. In the large joints the symptoms frequently call sooner or later for amputation; in the knee, though the wound may not be very large, or lacerated, immediate amputation is the rule.

The longer a fractured limb has remained at rest, the more difficult is it to overcome the stiffening of the joints. If there is also a certain degree of irritation about or within the joint itself, owing to the seat of the fracture, the stiffening will be greater and more stubborn.

In even the simplest intra-articular fractures, we should beware of promising that the limb will recover its full power and motion. This may occur, but only exceptionally.

When a fracture has lasted six months without consolidating, it would be unwise to affirm that it will do so under any treatment we may adopt.

On the whole, then, to form a judicious prognosis, the surgeon should take into account the age of the patient, the sex, the state of strength or debility, of health or sickness; the circumstances of the fracture, as regards its seat, its nature, its recent or ancient date, its complications; and lastly, the plan of treatment already pursued, as well as that proposed for the future.

ARTICLE VII.

TREATMENT.

The treatment of fractures consists, generally speaking, in the fulfilment of two principal indications: to reduce the broken ends, and to keep them in place until consolidation is complete. There are some cases which do not call for reduction, where the relative position of the fragments is unchanged, and we have only to maintain them sufficiently at rest. But this apparent simplicity conceals numerous complications; besides the first attentions required by the patient, the mere reduction gives rise to various important questions as to the position to be given to the limb, the means of effecting the object, and the precise time to employ them. Again, as to retaining the fragments in place, four great problems are to be solved: the

apparatus to be used, the time at which to apply it, the time to renew it,—if, indeed, it is to be renewed at all,—the time when motion is to be impressed upon the limb; lastly, during the time requisite for consolidation, as well as subsequently, the surgeon must be on the watch, so as to prevent or correct any symptoms which may arise. All these difficulties, met with in the treatment of simple fractures, are still more urgent in those which are complicated; and, after all, in more unfavorable cases, we may have to remedy either of these three troublesome results of fracture: anchylosis, deformity, and non-union.

§ I.—*Of the First Attentions to the Patient.*

When a person sustains a fracture of the upper extremity, he can easily go himself to find a surgeon; the injured member being supported by the hand of the sound side, or at most requiring merely a sling.

It is not so when the lower extremity is involved. The patient must be raised up and carried, and his clothes must be removed; all which is very painful unless skilfully done. A. Paré, just as he was going on board a boat, had his left leg broken by a kick from a horse. He says:

"Ayant reçu le coup, et craignant que le cheual ne ruast derechef, ie desmarchay vn pas: mais soudain, tombant en terre, les os ja fracturés sortirent hors, et rompirent la chair, la chausse et la botte, dont ie sentis telle douleur qu'il est possible à homme d'endurer. . . Soudain fus porté dans le bateau pour passer de l'autre part pour me faire panser. Mais le branlement d'iceluy me cuida faire mourir, pourceque l'extremité des os rompus frayoit contre la chair, et ceux qui me portoient n'y pouuoient donner ordre. Estant hors, fus porté en vne maison du village, auec plus grande douleur que ie n'auois enduré au bateau; car vn me tenoit le corps, vn autre la iambe, l'autre le pied; et en cheminant, l'vn haussoit à senestre, l'autre baissoit à dextre. Enfin, toutesfois, on me posa sur vn lit pour vn peu reprendre mon haleine, où, pendant que mon appareil se faisoit, ie me feis essuyer tout le corps pourceque i'estois en vne sueur vniuerselle; et si on m'eust ietté en l'eau, ie n'eusse esté plus mouillé." *

* ["Having received the blow, and dreading lest the horse should repeat it, I made a step backward; but suddenly falling to the ground, the broken bones stuck out, piercing the flesh, the stocking, and the boot; from which I felt the most intolerable pain. . . . Very soon I was carried to the boat, to be taken to the other side, that I might be dressed. But the jolting thus caused nearly killed me, since the broken ends of the bones tore the flesh, and those who bore me were unable to fix them. On landing, I was removed to a house in the village, with even greater suffering than I had endured in the boat; for one car-

This sad picture is too often repeated on the field of battle, where the wounded must be set astride of guns, raised by their garments, or rolled up, so to speak, in a cloak, to be dragged rather than carried. How often, cries Percy, have we seen officers and soldiers thus carried sometimes half a league from the field! and it must be confessed that, but for this increase of suffering, many brave men would still have retained life and limb.*

For my own part, I regard these jolts in carrying as one of the chief causes of the spasmodic startings of the muscles, and of the extensive inflammation so often supervening on complicated fractures. It is therefore important to dwell on this point; *principiis obsta.*

In cities and towns it is but rarely that a hand-barrow or a litter cannot be found, on which to lay the patient. In Paris, the litter used consists of an oblong frame on four legs, with a bottom made of stout linen; the part supporting the lower limbs is horizontal; the remainder, corresponding to the trunk and head, forms an inclined plane. On the frame are placed iron rings, to which may be fastened a sheet for protecting the sufferer from the air, light, etc. For the first removal of a patient, there is really nothing simpler or better.

But an army could not carry a sufficient number of such litters; something at once of simpler form and more portable must be devised. We made use in Poland of the litter of Goercke, consisting of two long and solid wooden bars, each bearing an iron branch about two feet long, to be fixed in a corresponding tenon in the other; constituting thus the frame. The bottom was formed of an oblong piece of strong ticking, having at its longer edges wide hems, within which the bars could be passed. Lastly, braces were adjusted to the handles, to go over the shoulders of the bearers.

At first sight it would appear still simpler to fix the ticking permanently to the bars, by wrapping it around them; the litter would take up no more room, and would be more readily set up. But the cloth when so fixed is soon worn by the rubbing, or rots by exposure to rain and dirt; so that the greater apparent simplicity would involve greater trouble in preservation.

Even as it is, Goercke's litter is but of limited use. Suppose a battle which has been expected, and time given to arrange everything; these litters are at the ambulance, awaiting bearers. The wounded fall in the ranks; commonly, there are only their comrades to remove them; and there is no time for them to go to the ambu-

ried my body, another my leg, another my foot; and in walking along they did not keep in step. At length, however, I was laid on a bed, to take breath; and here, while the dressings were in preparation, I caused them to wipe my whole body, being in a perspiration all over; had I been plunged into water, I should not have been more thoroughly wetted."]

† *Histoire de la Vie et des Ouvrages de Percy,* par Laurent, p. 381.

lance for the litters. But on a sudden alarm, in a hasty skirmish, the litters lie in the wagons, there being no time to take them out. They are therefore really useful only after the action, in collecting the wounded on the field.

Percy solved the problem by instituting companies of bearers. Every man was provided with a fir-tree pole six feet long, which could be used at need as a weapon, having an iron point; this was the side-piece of the litter; every man carried also upon his knapsack a cross-piece of walnut, bored at each end with a round hole through which to pass the side-piece, and supported on two legs, so as to raise the litter about ten inches from the ground. The cloth, carried like a girdle or scarf, had two wide hems like those of Goercke's.*

Percy's plan was adopted by a decree of 1813; political events, however, prevented its being carried into execution. But I dare say that every military surgeon who has been present at serious actions would recognise its importance, and the fact that the medical service of an army cannot be properly insured without an organisation of this kind.

Too often, moreover, whether in civil or military practice, the surgeon is without any convenient means of transport; he must then extemporise one. M. Mayor has pointed out how with poles, ladders, or boards, connected by nails or cords, covered with a mattress, or with hay or straw, one might make on occasion quite a convenient litter.† Percival Pott had a similar accident to that of A. Paré; falling from a horse in the street, in London, he broke his leg, and the jagged end of the bone pierced the skin. The experienced surgeon at once sent for two sedan-chair-men with their poles, and waited patiently, stretched upon the pavement, although it was in the midst of January. When they arrived, he purchased a door, and made them nail their poles to it; and was thus carried a long distance, to his own home.‡ Pott recovered without any bad symptom; Paré suffered from violent startings of the limbs, and from an abscess of long duration.

I cannot omit noticing here a very just remark of Earle's; it is that in such cases we too often make use of a carriage, which always aggravates the pain, by the jolting, the necessarily confined posture, and the difficulty of getting in and out.

To raise the patient and place him on the litter, the easiest way is this: a strong man, standing on the sound side, puts one arm round the patient's chest, and the other hand under the pelvis, while the patient's arm is placed around his neck. If the patient is very heavy, it needs a special assistant to support the pelvis, and in all

* *Histoire de Percy*, par Laurent, p. 379.

† Mayor, *Fragments de Chirurgie Populaire*, p. 35.

‡ *Histoire succincte de la vie de P. Pott*, par Earle; *Trad. franç. des œuvres de Pott*, tome iii, p. 8.

cases a second should support the sound limb. Two others sustain the broken limb by its two extremities, taking care gently to extend it, and to keep it in the straight position. At a given signal, the patient is raised, and the litter slipped under him, when he may be lowered upon it. In the same way he may be transferred from the litter to his bed, or from one bed to another.

The bearers should be as nearly as possible of the same height. If one is taller than another, the tall one should be placed at the patient's feet, so as not to have the weight of the body pressing on the broken limb. For the same reason, in going up a slope, or a staircase, the feet should be foremost, and the reverse in descending. Dupuytren adopted, at the Hôtel-Dieu, a measure of manifest utility; it was to use the lower story for fractures, to obviate the inconvenience of carrying them up to the higher ones.

[At the Pennsylvania Hospital, a large hoisting machine is employed, with a platform capable of accommodating a bed and several assistants; on it severe cases of all kinds are constantly and easily raised to the second and third stories.]

It is well also to regulate the step of the bearers. The fewest possible jars will be caused, when they keep step; in order to which they must set out right.

The patient being brought close to his bed, his clothes must be removed. To do this, the broken limb is steadied; those garments are taken off which give little difficulty in so doing; those covering the fracture itself should be ripped or cut off with scissors; then the bed being made ready, the covers thrown off, and the apparatus arranged on the sheet, the patient is carefully moved into it.

Finally, there is a yet more difficult case, when we have to bring up from the bottom of a mine a patient with a broken thigh or leg. In the majority of mines, there is no other way than to drag the sufferer along narrow galleries to the nearest shaft, and to raise him in the same bucket which serves for hoisting the mineral. M. Vallet has devised for this case a very simple and ingenious apparatus, called the *lit de mine*. It is a sort of elongated chest, about sixteen inches wide, much like a coffin, but uncovered, and with a bottom somewhat concave; it is furnished with a thin mattress, having toward the centre a ridge about four inches high, so as to afford a sort of seat when the patient is nearly in the vertical position; the sides are hinged to the bottom, thus allowing the patient to be placed in position with the least possible lifting, by turning them down; when raised, they are held together by hooks. The head-board is likewise hinged; the foot-board is composed of two separate and independent parts, that one only being fastened which corresponds to the sound limb, so that this alone is made firm. The patient, laid on the bottom, is also held in place by girths fastened behind him, and crossing one another over the chest, pelvis and thighs.

This box is carried horizontally in the galleries of the mine, either by leathern handles, or by wooden ones which may be used at will as feet, in case of having to stop in muddy or wet places. Arrived at the shaft, the box is attached to the rope by means of four chains, two at its upper end and two about the middle. If the shaft is narrow, the box should go up nearly vertically; if wide, its position should be made more or less horizontal by shortening the chains attached at its middle part. When brought out from the shaft, the box becomes a hand-barrow, in which the patient may be at once conveyed to the place where he is to remain during the treatment.

The usefulness of this apparatus is not limited to mines only; and as the author points out, its construction fits it, in case of inundation or fire, for rescuing bedridden patients who are placed in danger.*

§ II.—*Of the proper position for the Limb.*

We shall not here discuss the position to be given to the limb in each particular fracture; this will be taken up at the proper time and place. But we must first of all inquire what should be the general attitude of the member; whether it should be flexed or extended.

For the upper extremity, it is almost invariably the custom to keep the elbow at a right angle, the forearm being supported in a sling. Some exceed this degree of flexion, shortening the sling so that the wrist is above the level of the elbow. If, however, the patient keeps his bed, the limb, laid upon cushions, is less bent; but it is remarkable that it never has been proposed, except in fractures of the olecranon, to put the upper extremity in the extended posture.

On the contrary, from the earliest times, extension has been preferred for the lower extremities. To explain and justify this difference, Hippocrates alleged the habits of the limbs, the upper remaining flexed by preference, and the lower extended. Galen found a better reason; he studied the *mean figure* of the limbs, that is to say, the posture which, avoiding the extremes, fatigued the muscles least, and could be longest maintained without pain; and he found this to be no other, even in the lower extremity, than a certain degree of flexion. But as this would have led to results too directly opposed to the practice of Hippocrates, Galen preferred a middle course; and adducing the law of habit, he alleged only that some persons who followed sedentary pursuits remained constantly seated and with their lower limbs flexed, and hence that in them, as an exception, flexion was preferable. Moreover, in limiting the degree of his reform, he forgot what alone could give it some reality, viz., the means to be employed. He says indeed that he has seen his ideas

* *Gazette Médicale*, 1835, p. 455.

verified by experience; but he neither describes any new apparatus, nor any modification of the old. Later, Fabricius of Acquapendente extolled more highly than did Galen himself the utility of the semiflexion of the limbs, though like Galen he shrank from putting his theory into practice; and it was not until the eighteenth century that it was made, by Pott, the general rule for the treatment of fractures of the lower extremities.

Pott's doctrine is founded at once on theory and on practice. He commences by establishing that from the muscles arises the whole difficulty of reduction; the resistance depending on the position of the limb putting them in a state of tension. The natural consequence is that the limb should be so placed as to relax the muscles, making them offer the least possible resistance; this position being that of semiflexion. "Moreover," adds Pott, "all that I say is based on a long experience of my own, and on that of several other surgeons; upon repeated trials in a great many cases, so successful that I do not fear to say that such as will follow our plan will be as successful as we have been."

Pott's method was in fact soon and generally adopted throughout England; but in France, Desault had authority enough to cause its absolute rejection. This he based upon several reasons: the difficulty of making the necessary extension on the broken bone;—the impossibility of accurately comparing the two limbs;—the inconvenience of lying on the side, and the injurious pressure sustained in this position by the trochanter major;—the derangements to which the fracture is liable when the patient goes to stool;—the difficulty of firmly fixing the leg;—the impossibility of adopting this method when both limbs are broken;—and lastly, the results of experience. Of these reasons, the first two are really of singular insignificance; the others have reference only to the decubitus advised by Pott, and not to the method itself; and as to this great word *experience*, which would seem to decide the question, it will be enough to say that Desault had only tried semiflexion in two patients, one of whom, in spite of the most scrupulous attention, had a considerable degree of shortening.

But Bichat added another and more specious objection, and one which had more influence. What we gain by relaxing some muscles, said he, we lose by the tension of others; the knee cannot be flexed without stretching the quadriceps; the rectus femoris, relaxed by flexing the thigh, is made tense by flexing the leg; and lastly the superior and posterior muscles of the thigh, as the gluteus maximus, are also made tense. Dupuytren has triumphantly refuted this argument of Bichat. It is true that if the limb be placed in extreme flexion, the extensor muscles may be rightly said to be so stretched as to destroy the good effect from the relaxation of the flexors; just as in the extended position, the relaxation of the extensors is more

than counterbalanced by the tension of the flexors. But in semi-flexion, or even in flexion at an angle of 135°, no muscles are stretched; all partake of the relaxation, which is the best condition for reduction.

Lastly, M. Bonnet has very recently resumed this discussion upon a new basis, opposing semiflexion from reason, experiment, and clinical results.* His argument does not, however, differ from that of Bichat, and hence need not be here repeated. What he calls clinical results are merely judgments, more or less unfavorable, passed upon semiflexion by Larrey, MM. Cloquet and Bérard, Vidal and Gerdy; authorities opposed to other authorities, serving at most only to keep the balance undecided. There remain the experiments, to be more seriously examined.

M. Bonnet's experiments, although arranged by that author in five series, are all comprehended in this: in a dead body, the legs being stretched out, he made at the outer side of the thigh an incision two or three inches long, and by means of this opening he sawed through the femur obliquely. At once there was an overlapping of nearly an inch, which, however, readily disappeared on slight traction being made on the leg. If, then, the body was moved so that the knees projected over the edge of the table, and the leg was strongly flexed, the thigh still extended from the pelvis, extension was attempted in vain by the forearm placed in the ham; in proportion as the leg was flexed there occurred a gradual shortening, which was at least one inch when flexion was carried to a right angle, and which no traction, however powerful, could overcome. The author has not confined himself to the mere result of his experiments; he has sought for them an explanation which should enable him to apply them to the living subject; and this he has worded as follows: *The displacement of the lower fragment, induced in fractures of the femur by flexion of the knee, should be attributed to the new relations assumed by the articular surfaces, and to the pressure of the condyles of the tibia upon the condyles of the femur.*

What strikes one at once here is, that the semiflexion produced by M. Bonnet in the dead subject is a position which cannot be given to living patients, and entirely different from surgical semiflexion. But, not to dwell on this objection, I repeated his experiments, and obtained the following results.

If the femur of a body in a state of cadaveric rigidity be sawed through, the effect will be nearly that indicated by M. Bonnet. A simple reflection will show that it cannot be otherwise. The muscles of the thigh, stiffened in the extended position, are like cords nearly incapable of being stretched; it is well known how much force must be used to bend the knee under such circumstances; M. Bonnet himself has admitted that the tension of the quadriceps is so consider-

* Bonnet, *Mémoire sur les fract. du fémur*, etc.; *Gaz. Médicale*, Aug., 1839.

able that the knee cannot be flexed without rupturing a good many of its fibres. The femur being sawed through, the muscle resists flexion quite as strongly; it is the bone which yields, by overlapping. Extend the limb again; the quadriceps, no longer stretched, offers no resistance; the flexors, stiffened in a state of elongation, and not in any way rendered tense, are equally passive. Reduction is then easy in the extended position, because the muscles have become stiffened in this position, and not because of the position itself.

But if this be so, then by dividing the femur in a body stiffened in a state of semiflexion, we ought to get directly opposite results. I have made this counter-experiment; and then, as might be foreseen, reduction was easiest during flexion; but in extension the stiffness of the flexors rendered it impossible. Lastly, I have repeated these experiments in subjects without cadaveric rigidity, all the muscles being loose and flaccid; and then there was in no position of the limb either overlapping or resistance, except, indeed, from the weight of one or the other fragment.

Hence we see what is to be thought of M. Bonnet's experiments, and of the pretended pressure exerted during flexion by the condyles of the tibia upon the femur. The condyles of the tibia cannot act of themselves, except by their weight; to exert any pressure whatever, they must first themselves sustain it; and according to the direction of the pressure they sustain, do they sometimes press more during flexion, and sometimes during extension.

In fine, the only active resistance to be overcome in the reduction of fractures belongs entirely to the muscles; and this simple fact suffices to show beforehand the nullity of experiments made on the dead body. Muscular action cannot be studied except where it exists; hence experiments must be made of necessity upon the living subject. I have therefore proceeded as follows.*

In a rabbit, I passed an iron pin into the substance of the trochanter, and another into the external condyle, so as to have in their projecting heads two fixed and invariable points for measurement; after which I broke the thigh, and made the fragments overlap. Then proceeding to the reduction, I put a counter-extending noose under the perineum, within the tuber ischii, fixing it above to a firm hook; the extending loop surrounded the thigh immediately above the knee, and was stretched by weights. I could thus measure the elongation of the limb, under the traction of the same weight, in different positions; the results were as follows:

	Complete Extension.	Moderate Flexion.
Traction with 2500 grammes,	75 millimètres.	80 millimètres.
" " 1750 "	70 "	75 "
	Complete Extension.	**Moderate Flexion.**
[Traction with about $6\frac{2}{3}$ pounds Troy,	$2\frac{1}{2}$ inches.	$2\frac{2}{3}$ inches.
" " " $4\frac{3}{4}$ " "	$2\frac{1}{3}$ "	$2\frac{1}{2}$ inches.]

* *Examen des doctrines chir. relatives à la réduction des fractures; Journal de Chirurgie*, 1845.

In another rabbit, placed under precisely similar conditions, only with the extending loop placed on the leg above the malleoli, and the flexion of the knee effected by means of a double inclined plane, the results were the same:

	Complete Extension.	Moderate Flexion.
Traction with 2000 grammes,	60 millmètres.	65 millimètres.
" " 1500 "	57 "	62 "
" " 1000 "	55 "	60 "

	Complete Extension.	Moderate Flexion.
[Traction with about $5\frac{1}{3}$ pounds Troy,	2 inches.	$2\frac{1}{6}$ inches.
" " " $2\frac{1}{2}$ " "	$1\frac{17}{20}$ "	$2\frac{1}{15}$ inches.
" " " $2\frac{3}{5}$ " "	$1\frac{1}{2}$ "	2 inches.]

In a third rabbit, I performed the same experiment on a broken leg. A weight of 500 grammes [about one and two-fifths pounds Troy] brought the limb down eight centimètres [two and two-thirds inches] during extension, and eight and one-quarter centimètres during flexion.

We see, then, that when muscular action is still within physiological bounds, in all recent fractures, moderate flexion is constantly found more advantageous than extension; and that, with an equal power, it allows greater stretching of the muscles; the difference being slight in the leg, but amounting in the thigh to one-eleventh or one-fifteenth. When the muscular contraction assumes by its degree a pathological character, the results vary somewhat, according to the degree of inflammation, and there is even a point at which the influence of position seems superseded by the violence of the contraction.

Thus in the second of my rabbits, the fracture of the thigh being of forty-eight hours' standing, and the muscles giving way a little, under a force of three kilogrammes, [between seven and eight pounds Troy,] the limb when extended was sixty millimètres in length, when slightly flexed, sixty-five.

In the first, the inflammation being more active, it required more than six kilogrammes to elongate the extended limb to seventy millimètres; even in semiflexion it hardly reached quite seventy-three.

Lastly, in the one in which I broke the leg, the inflammation entirely did away with the slight advantage which in the physiological condition would have resulted from the semiflexed position.

But apart from these experiments, which would seem to me definitely to settle the question, are there not sufficient reasons against the extended position in the treatment of fractures? It is certain that complete extension, like complete flexion, is a fatiguing and painful position when kept up long. If we would seek reasons for

this incontestable fact, anatomy shows us that the ligaments are stretched, and the articular cartilages pressed against one another. Physiology in its turn shows that certain muscles are put into a state of forced tension; and experiments, in which by section of the nerves the muscles were deprived of all but their vital contractility, have shown me that muscular action opposes as well complete extension as complete flexion, ceasing to act only when the limb is removed from either extreme.* Lastly, clinical experience would furnish, in favor of the intermediate posture, at least two irrefragable arguments, which would only confirm our anatomical and physiological data: the first, upon which I have already dwelt sufficiently, (see p. 118,) is that extension renders the patient more liable to stiffening and to anchylosis; the second is, that semiflexion facilitates difficult reductions. On this point, opponents as well as adherents bear the same testimony. "Sometimes," says Boyer, "the difficulty of the reduction arises from the forced extension of the limb and the unequal stretching of the muscles; it may be obviated by putting the limb in a state of semiflexion."

Whence, then, comes the difference of opinion in this respect, and the reproach cast upon semiflexion? Several reasons may be given. In the first place, more is expected of the position than it can accomplish; and it should be observed that its advocates themselves, by exaggerating its advantages, have justified these criticisms. That it facilitates reduction appears to me beyond any sort of doubt; but it is rarely sufficient to produce it, or to maintain it when produced.

In the second place, it is not sufficiently determined to what degree of flexion the limb should be brought. Pott defined almost mathematically the half-way position; and in the figures illustrating his process, we see the leg flexed on the thigh at an angle of 112°. The double inclined plane of Sir C. Bell presents an angle of 115° to 125°. Sir A. Cooper widened his to 135°; but it is rarely that I flex the knee to more than 150°, and frequently I make the angle much greater, especially in fractures of the leg. In my experiments on animals, I have generally found extreme flexion less favorable than extreme extension, and flexion to one-fourth better than semiflexion, properly so called. Experience has also taught me that the degree of flexion should not be the same in all subjects, or in all sorts of fractures; and, particularly in cases with active inflammation, it is sometimes indispensable to deviate from the usual rule.†

* See my *Anat. Chirurgicale*, tome i, p. 108.

† The brothers Weber have proved that the extent of motion of the knee from extreme extension to extreme flexion, measured in but two subjects, differed by nearly 17°. Certainly the differences found in measuring a larger number of subjects would be much greater. (See *Traité mécanique des organes de la locomotion*, in *l'Encyclopédie Anatomique*, tome ii, p. 344.

Lastly, there is often a mischievous confusion made between the method itself and the means of applying it. Thus the posture on the side, advocated by Pott, but so vehemently opposed by Desault, has long fallen into disuse except in purely exceptional cases. I have seen employed at the Hôtel-Dieu, within twenty years, inclined planes of wood, or even of iron, whose angle, nearly 90°, excoriated the ham. Dupuytren erred in a different way, making inclined planes by means of pillows, which sunk in from the weight of the knee; such modes of applying the method are evidently improper.

It is not enough to prescribe a position for a broken limb; it must be maintained fixed and immovable till consolidation is complete, and be guarded against all sources of displacement. Among these are prominent, (1) a want of solidity in the plane sustaining the limb; (2) partial pressure, causing intolerable pain; (3) the weight of the covering, of the limb, or of the trunk; (4) the movements of the patient.

In fractures of the upper extremity, the patient can generally sit up; semiflexion is maintained by supporting the arm in a sling, or in a hollow splint, fixing the whole to the side by a bandage, if necessary. When the patient is obliged to keep his bed, the limb is placed on cushions stuffed with oat-straw; but these cushions soon sink in, causing serious inconvenience. To put a board under the cushions is neither easy nor certain, on account of the elevation at which the limb is to be kept; the suspending apparatus of M. Mayor, although doubtless useful, involves much trouble; the best plan, therefore, is to watch the cushions, and correct their displacement whenever it occurs.

Fractures of the lower extremity, which nearly always imperatively require that the patient should keep his bed, demand also more care, especially on account of the weight of the limb. J. L. Petit was perhaps the first to recommend the use of mattresses without any feather bed, and to put between the two mattresses a board long enough to reach from the foot up to the hip. Duverney pointed out another method more nearly approaching to the modern hyponarthecia. It requires a board long enough to reach from the foot to the buttock, and two or three inches wider than the limb itself; this is covered by a firm hair mattress of the same length and breadth, and both are covered and held together by a sheet well stretched and sewed over them. On this board rests the injured limb, the sound one being placed on two pillows, one for the buttock and one for the leg and thigh; lastly, a compress of sufficient thickness is put under the ham, to prevent its being displaced. These two methods are essentially adapted to the extended position of the limb; the choice between them is matter of indifference, the main point being the fulfilling of the existing indications. When semiflexion is resorted to, it is much more important still to have a solid plane the whole length

of the limb, and the employment of a wooden or metallic inclined plane becomes indispensable.

But in looking to the solidity of the sustaining apparatus, we must guard against such firmness as to give rise after a time to painful pressure. Long-continued lying on the back is usually said to give rise to sloughing over the sacrum, in patients of advanced years. With a view of obviating this danger, J. L. Petit proposed to make a hole in the mattress at the part corresponding to the sacrum; and more recently there has been contrived an apparatus, in fact several have been invented, so that the patient may be raised, and the buttocks exposed to the air, without disturbing the extremities. Daujon's bed, employed in the Parisian hospitals, will give an idea of all the rest. It consists of a movable wooden frame, having stretched on it a ticking pierced at about the centre with a hole five or six inches in diameter; a mattress and sheet, with corresponding openings, are placed upon this ticking; the patient is placed on this mattress, and by means of four cords, one attached to each corner of the frame, passing over pullies at the tops of the bed-posts, and meeting on a windlass, it will be seen that the frame, mattress and patient may all be raised together by turning the crank; and thus the sacrum, situated opposite to the central orifice, may be at will relieved of all pressure. These arrangements are useful also in another respect, which is in allowing the patient to go to stool without at all disturbing either the trunk or the limbs; and it may be well to remember that the perforation of the mattress for this purpose dates back to the times of Paulus Ægineta. But while their convenience is recognised, their importance should not be exaggerated; most commonly there is no difficulty about the evacuations, and as to sloughing over the sacrum, provided that the patient rests on a properly stuffed mattress, old persons are no more liable to it than others; I shall elsewhere recur to this point in speaking of accidental symptoms.

Pressure on the heel rarely causes sloughing; much oftener it causes severe and incessant pains. A. Paré, who had experienced them, relates that, to obtain relief, he had the heel raised up from time to time; again, he had a down-cushion placed under it, as well as under the buttocks; afterwards he had a sort of hollow tin splint made, so notched under the heel as to make no pressure upon it; and to protect it still more, he kept the splint off the skin by a thick compress slipped under it. Duverney proposed to put under the heel a piece of sponge, which would be at once supple, resisting, and elastic. Some surgeons of his time used *faux-fanons*, or a roller with two heads, between which the heel was lodged; only it was recommended to have the bandage so wide that the roll on each side should reach up as far as the commencement of the calf of the leg. For my own part, I satisfy myself with placing between

the heel and calf compresses of wadding, so that the leg may have equal support at all points of its posterior surface, the heel only being left free.

These precautions should be observed as well when the limb is extended as when it is semiflexed; but when the latter position is preferred, and a double inclined plane is used, other parts may likewise suffer from undue pressure. The ham suffers when the angle is too sharp, or insufficiently covered; but by reason of the wide angle I employ, I have not had a single patient to suffer from this. The tuber ischii sometimes gives more trouble. The head and shoulders being raised by the pillows, the trunk tends to slip down toward the bottom of the bed; and the tuber ischii comes to press either on the surface or on the upper edge of the femoral part of the splint. If the fracture is in the leg, this portion can be easily shortened; but in fractures of the femur, where the full length of it is needed, we must carefully pad it so as to lessen the pressure, and if necessary, keep the trunk up by means of a loop passed under the perineum and attached to the head of the bed.

The weight of the coverings may do harm in two ways: sometimes by pressing at the seat of fracture, sometimes by acting on other points of the limb, so as to twist it. It has therefore become customary to sustain them by hoops placed opposite all the points needing protection. In simple fractures of the lower extremity, I usually protect the point of the foot by means of the high foot-piece of the double inclined plane.

It is in fact upon the toes that pressure is at once the most painful and the most injurious, because it favors the natural tendency of the foot to fall outward. Even without pressure, if left to itself, its own weight will often throw the foot over in this direction; and it is important to hold it up either by means of a cushion, a foot-board, or two lateral splints.

Another much more serious danger, and particularly because it has attracted less attention, arises from the weight of the trunk itself. It has already been said that by reason of the elevation of the head and shoulders, the body tends to slip down in the bed; and besides the inconvenience so caused, by pressure on the tuber ischii, the trunk cannot slip down without pushing on the upper fragment, tilting it up, and making it overlap the lower. This is the reason why even when permanent extension is not called for, we must always keep the body up by means of a perineal loop; and this necessity will be still more clearly shown in treating of the movements which the patient may be allowed.

This is not all; while the fractured limb and the corresponding half of the pelvis are supported by the apparatus, the other half of the pelvis and the other limb lie unconfined on the mattress, making in it a hollow which daily becomes more marked, so that the whole body at

last inclines toward the sound side, drawing along with it the upper fragment, which thus inevitably forms an angle with the lower. In very fleshy subjects, the danger is augmented by their weight, but it is also more easily counteracted; for we need only have the board between the mattresses, as proposed by J. L. Petit, lengthened so as to reach a little beyond the buttocks, and widened so as to equal the bed, in order to give an equable support to the pelvis and limbs. If on the contrary the patient is spare, giving reason to fear the effect of pressure upon the sacrum by the board, we must be satisfied with supporting the sound side by means of cushions, after Duverney's method; but with the indispensable precaution of daily watching and arranging them.

[It may be doubted whether the mere weight of the patient does not tell equally upon the skin where there is a thick layer of fat *above* it, and where there is but little; and perhaps the advantage of that layer, however great, may be counterbalanced by the additional weight which its presence involves.]

It would now remain for us to inquire how the different movements of the patient derange the position of the limb, and how to obviate such movements; but this subject belongs to a most important question, to wit, what motion may the patient be allowed, if any? which will be discussed in a separate section.

Now, the limb being placed in a suitable posture, and all the precautions necessary to maintain this being taken, we must, unless for some special reason, proceed to the reduction.

§ III.—*Of the Reduction.*

The operation of reduction has for its object the correction of the displacement of the fragments, and the giving to the bone its natural direction, form and length.

From this simple definition, we may judge of the folly of some surgeons in attempting to reduce fractures in which there is no appreciable displacement. There are two very distinct cases in which all attempts of this kind are absurd; first, when it is ascertained that there is no displacement; secondly, when one cannot establish the fact of its existence, on account of the depth of the fracture or the swelling of the soft parts. I might add still a third case, when although the displacement is completely made out, we have no means of reducing it.

It is evident, moreover, that the process of reduction varies with the displacement itself. When there is merely an angular deviation, it suffices to bring the lower fragment into a suitable direction, and the reduction is effected. It is so also in some cases of displacement by rotation, when the fractured surfaces are smooth, and glide readily upon one another. Transverse displacement, on the contrary, ge-

nerally obliges us to resort to coaptation; this is a process in which we sometimes press with the thumbs on the projecting fragment, so as to push it back to the level of the other, and sometimes, grasping one fragment with each hand, we push them back simultaneously. These means fail when in a serrated fracture the ends are so interlocked that they must be separated in order to overcome their impaction; each fragment must then be drawn in a different direction. These tractions receive the general name of *extension;* the term is however usually limited to the force exerted on the lower fragment, that on the superior being called *counter-extension.* They are much more necessary when there is impaction or overlapping; when on the contrary the fragments tend to separate, as in fractures of the patella, the limb must be first placed in the position bringing them closest together; after which the reduction consists merely in pushing them toward one another.

The majority of these processes offer little difficulty, and need no further description. But the extension of the limb is a far more delicate matter, and suggests various questions.

The first question which occurs is as to the agents to be used in making traction; in this respect there may be counted three very different lines of practice. According to Desault, Boyer, and nearly all the modern school, the hands of assistants always suffice. Celsus, Paulus Ægineta, the Arabians and their disciples, and more recently Duverney and most of the *Académie Royale de Chirurgie*, resort to loops in difficult cases. Lastly, Hippocrates in ancient times; A. Paré, Fabricius of Acquapendente, Fabricius Hildanus, Wiseman and J. L. Petit, in modern times; and Monteggia, at a date still nearer to our own, recommend the use successively of the hands, of loops and of machinery, as we may find them necessary. "If the extension made by the hands of the assistants is sufficient," says Hippocrates, "we should make use of it alone; for it is absurd to apply apparatus where it is not needed. But if the strength of assistants does not suffice, we must resort to more powerful means, and then the most convenient should be selected."

Nothing more proper could have been said, in our opinion. There are cases where the surgeon does not even need any assistants, he himself easily making extension and counter-extension; such are fractures of the phalanges, and even those of long bones in very young subjects. At other times the strongest muscles may be overcome by two assistants pulling in contrary directions, provided the limb affords sufficient hold. But when this hold is wanting; or when the muscles, from their number or from being irritated, are powerfully contracting, we cannot understand how the doctrine of Desault and of Boyer could obtain so general an assent, in spite of the contrary practice of all ages, and in spite of the facts daily opposing it. There is perhaps not a single fracture of the femur which could be

reduced merely by the hands of assistants, except it might be in children or in some debilitated subjects. I speak of quite recent fractures; when inflammation is set up, as just now said, even our apparatus will not suffice. This is still further the case when the fracture is of a month's standing or more; and Boyer reports two instances of fracture of the femur, one dating back forty days and the other four months, in which, notwithstanding the steady use of mechanical means, he could not bring the limb down to its natural length. I am well aware that many surgeons think themselves to have obtained reduction of fractured thighs by the hands of assistants, and as a result, consolidation without shortening; for myself, except in children, I have never seen a single one; and I would add that all the successful results thus stated are wanting in the only admissible proof, the exact measurement of the limb.

It needs only that one should try, or see tried, a reduction of this kind, to prove convincingly that counter-extension by an assistant holding the pelvis is entirely illusory. The assistant is hampered, he has no purchase, and can only exert a force equal to about thirty kilogrammes, [not quite seventy pounds avoirdupois.] Now to this force are opposed sometimes the forces of two other assistants pulling on the leg or knee; how much can the former resist?

The first rule for making counter-extension, which has been too much forgotton, is to employ such a retaining force that the tractile efforts, powerful as they may be, cannot overcome it, and will hence be expended in stretching the muscles. Thus for all fractures of the femur, for some fractures of the leg; in a word, for every fracture which calls for the employment of great force, I would have counter-extension made by means of loops attached to a fixed point, such as a ring built into the wall, as in luxations, or to the head of the bed. In this way only can we be sure of wasting none of the extending power, which may be made according to the necessity of the case, by assistants, by loops, or by machinery.

As to the question of the choice between these means, it may be solved in a general way, from scientific data; and in each particular case, by the measurement of the limb, revealing to the surgeon the effect produced.

I have demonstrated by direct experiment, that a robust man, pulling steadily and without jerks, and without any purchase for the body or feet, does not exert more than a force about equal to forty kilogrammes, [about ninety pounds avoirdupois;] and few assistants will reach this amount.* If we employ two or more, they want purchase on the limb, and hinder each other; so that much power is lost. Therefore, when one assistant is not enough, I make it a general rule to employ several loops surrounding the limb, in order

* See my *Anatomie Chirugicale*, tome i, p. 115.

that all the assistants may pull without being in one another's way; thus one can estimate approximatively the amount of force applied, and graduate it by increasing or lessening the number of assistants. Generally, in pulling on the lower extremity, the force may be much increased by setting the feet against the patient's bed; I have by experiment found it nearly doubled in this way.

It will be seen from this what power may be brought to bear with two or three assistants provided with loops; and in the majority of cases we may dispense with machinery. But it must be considered that the force exerted by assistants is very variable, and hard to regulate; a man may make a steady pull equal to thirty kilogrammes without setting his feet, or with such an advantage, may reach fifty kilogrammes; and this same man, by a sudden jerk, may go as high as ninety kilogrammes. There is therefore one precaution very necessary in employing assistants; they must be directed to act slowly, by steady traction; without any jerking, so as to avoid a sudden and violent pull, endangering the rupture of nerves, muscles and vessels.

Machines on the contrary are manageable, acting only gradually, and to a certain degree; they are not so capricious as human muscles, nor so rude as assistants; they are superior in every respect except in the difficulty of having them at hand; often also their complexity is an objection to them. The mechanical splint of Boyer is an excellent apparatus for producing extension in fractures of the lower extremity; but from its limited application it has nearly fallen into disuse. The glove of A. Paré, in favor with Fabricius Hildanus and with Ravaton, available both for fractures and luxations, has the disadvantage of needing a fixed point more difficult to find than that for counter-extension. The difficulty is the same in luxations as in fractures; and in both cases, I hold to the rule given by Hippocrates, that recourse should not be had to machinery, nor even to loops, unless in case of necessity; but that in all cases the power used should be in proportion to the resistance.

Another discussion has been started as to the point of application either of the loops or of the assistants' hands. Hippocrates attaches little importance to this; thus in fractures of the thigh, he would make counter-extension sometimes from the perineum, sometimes from the axillæ; and the extension at once from above the malleoli and above the knee, in order to avoid too strong traction on the latter articulation. J. L. Petit was the first to direct the force to be exerted only on the broken bone, with the double aim of losing no power and of protecting the neighboring joints. Dupouy and Fabre would give us exactly opposite advice; saying that the tractile force should never be applied on the broken bone itself, but on the bones situated immediately above and below it. Dupouy argues that we thus gain power, and Fabre adds that by acting on the injured bone, we compress, stretch

and irritate the muscles surrounding it, making them obstinately resist extension.* Lastly, Desault goes still further, recommending the removal of the extension and counter-extension as far as possible from the seat of fracture; in fractures of the thigh, for instance, he would draw on the foot and not on the leg, for the reason, says he, that *the power of the extending force is generally in inverse ratio to its distance from the opposition to be overcome.* This is a mistake in mechanics, long since pointed out; and Desault's practice in this respect has justly fallen completely into disuse.

It is otherwise with the doctrines of J. L. Petit and of Fabre; the former has its supporters chiefly in England, and the latter, embraced by Boyer, has become a sort of law in France. For my own part I adhere exclusively to neither, rather imitating the practice of Hippocrates. In fact, unless a very great force is to be applied, it makes little difference whether we put it on the lower fragment, or on the neighboring bone; the only determining motive is the greater facility of grasping the limb at either point. Thus in a recent fracture of the thigh, I prefer acting on the lower part of the leg, where the loops can be better attached; I have never known patients so treated to complain of pain in the knee; and the increase of power alleged by Dupouy seems to me to be only in the better purchase afforded. In the humerus, on the contrary, I prefer seizing the arm above the condyles, where I find the double advantage of a better hold and more direct traction. But when very great resistance is met with, I have several times known patients to complain of pain in the joints so stretched, even for a long time afterwards; the reduction of old luxations has afforded the most striking examples of this. Hence it is then preferable to follow the practice of J. L. Petit, or even to employ two loops for extension, in imitation of Hippocrates.

Whatever means are employed, extension must be begun in the direction of the lower fragment, to bring it down into the natural line of the limb; we must proceed slowly and without jerks, to avoid all risk of irritating or rupturing the muscles; and we must gradually increase the power till it is judged to be sufficient. It is very important that, during this time, the patient should make no movement of either of the other limbs, or even of the head; the injured limb shares more or less in any such motion, and the muscles are consequently thrown into action. I submitted to continuous extension, for twenty-four hours, a recent fracture of the femur; at the end of this time I removed the extending loops, to examine the state of the skin: the limb shortened hardly three or four millimètres. The patient tried to raise his head to see what was going on, and

* Dupouy, *Réflexions, etc.; Journal de Médecine,* 1767, tome xxvi, p. 170; Fabre, *Essais sur Différents Points de Physiologie, etc.,* Paris, 1770, 8vo, p. 242.

the shortening increased immediately to a centimètre; here the lower fragment was drawn up, the pelvis being still held in place by the loops attached at the head of the bed. Lastly, in some cases we may profit by Dupuytren's advice, and divert the patient's attention by conversation or by other means.

But while the extension is being made, what is there for the surgeon to do? He has two important duties to perform: to see that the extension is sufficient, and then to proceed to coaptation.

In fractures just beneath the skin, such as those of the tibia or of the clavicle, one can often follow with the eye the change of place of the fragments, and when they are seen to be in apposition, this constitutes the best proof of sufficient extension being made. But when the swelling obscures the bone, when powerful traction stretches the superjacent skin, and in all fractures buried within a mass of muscles, neither sight nor touch reveal anything regarding the amount of extension, either which is requisite, or which has been already effected.

If fractures always presented regular surfaces, it would be enough to give the limb its normal length, to allow the fragments to go into place; but as in the majority of cases they are irregularly serrated, we see the propriety of the rule given by Hippocrates, to carry the extension a little further. But, admitting this rule, the difficulty is to judge in each patient whether or not the requisite degree has been attained; Hippocrates is silent on this point, and none of his successors seem to have been aware of the omission. They all direct us to produce coaptation at all events, not considering that it may be impossible; for, I repeat, it is this possibility, or in other words the availability of extension, which must first be ascertained; and the only means of doing this is by a new measurement.

It is necessary therefore that while the assistants are pulling, the surgeon, duly acquainted with the shortening caused by the fracture, should measure the elongation which they produce, making them keep it up until the desired point is attained. We have given general rules for measurement while on the subject of diagnosis, and need not here repeat them. When at last all is made ready for coaptation, it is proceeded with as already directed.

Three difficulties may here occur to the practitioner. In the first place, he will not always find precisely the fixed points for measurement; he should then do his best toward supplying them, by bringing the two limbs together so as to compare them with his eye, aiding this by approximative measurement; in a word, by leaving to guess-work as little as he possibly can.

Secondly, after having to all appearance effected a complete reduction, we often find the shortening to recur at once when the extension is relaxed, so that nothing is really gained. This arises from the obliquity of the fracture, the surfaces being in no way prevented

from sliding upon one another; or we may have to deal with a multiple fracture, the splinters or intermediate pieces not affording due support to the ends of the main fragments. The only resource is then permanent extension, and all attempts at reduction should be suspended till this can be conveniently applied.

Thirdly, even after having proceeded as regularly as possible, it may happen that coaptation cannot be attained, some unexpected obstacle preventing the fragments from approaching one another. For this there are three principal causes: sometimes the edges or the surfaces of the fragments do not correspond; sometimes a splinter is caught crosswise; or lastly, there may be interposed some of the soft parts. It is not always easy, often it is impossible, to know which of these conditions we have to contend with. When we suspect the first, we may begin by using more powerful traction, so as to separate still further the fragments in the line of their length, and thus to allow the projecting portions to slip over one another. If this fails, we should move the broken ends in different directions, so as to bring different parts in contact, until the salient angles find the entering angles which correspond to them. Sometimes it is even necessary to make such a movement of circumduction that one fragment passes completely behind the other. I have seen a case of double fracture of the jaw in which reduction was impossible during life, and could only be produced in this way after death. M. Lisfranc has lately used it during life with complete success. The case was one of fracture of the leg downward and forward, the upper fragment of the tibia having pierced the integuments and passed back of the lower. The usual attempts at reduction having failed, the surgeon grasped the superior fragment, carried it by a semicircular movement before the other, and thus succeeded in reducing it.*

In the second case, when a splinter gets between the broken ends and prevents reduction, we may, if the splinter is superficial, cut down upon it and extract it, according to the bold advice of Lanfranc. But the prudent surgeon should compare the dangers of the presence of the splinter with those of the incision, and only decide after mature consideration of all the circumstances.

When, lastly, there is reason to believe that the fragments are kept apart by portions of the soft tissues, and every attempt at reduction has failed, the section of the intervening structures has been proposed by Laugier, who adopted it in the following case. A man, aged 55, had sustained a very oblique fracture of the right thigh; the upper fragment, which was very sharp, had pierced the muscles and aponeurosis, and even made a small wound of the skin; but the first attempts at reduction had disengaged it from the skin, which was nearly healed. The end of the fragment, however, rested be-

* *Gazette des Hôpitaux*, Aug. 3, 1844.

neath the skin; and any attempt at reduction only pushed it against the aponeurosis. M. Laugier introduced the tenotome at two different times; but in spite of the division of the tissues, reduction was impossible; an abscess formed at the seat of fracture, and the patient died of purulent absorption.* This result is not, to be sure, very encouraging, and perhaps a direct incision through the skin would answer the purpose more readily. The practitioner must, however, make his choice; to abstain from operating in such a case would cut off nearly all chance of consolidation, and condemn the patient to one of the worst of infirmities.

This attempt of M. Laugier leads us to speak of an operation of the same kind, intended to accomplish reduction in spite of muscular contraction, viz., cutting the muscles across; a plan advocated by Celsus, but only in cases of compound fracture. In 1840, M. P. Meynier, and subsequently M. Laugier, divided the tendo Achillis subcutaneously, in fractures of the leg. M. A. Bérard has thrice done the same operation in fractures of the external malleolus; and on another occasion he cut not only the tendo Achillis, but also the tendons of the peronei. M. Meynier has not reported the result of his case; of the five others, three are dead, and it is not known of the two cured whether they walk as easily and firmly as before.† We must therefore consider this as a last resort, which should be used with great caution, and only after the failure of all other means.

§ IV.—*Of the proper Time for attempting Reduction.*

This question has presented itself ever since the earliest times, and has been variously solved by practitioners. Thus, among the cotemporaries of Hippocrates, some waited until the third or fourth day, others until the seventh. Hippocrates opposed both these plans. According to him, extension should be attempted on the first or second day; but on the third inflammation begins to develope itself, and our first object should be its abatement. This usually occurs toward the seventh day, sometimes later; in all cases, we should wait till there is no more inflammation or fever, before resuming our attempts at reduction.

This doctrine, reproduced by Celsus and by Galen, was sustained by Albucasis among the Arabians, and by Lanfranc among their European followers. It resumed all its vigor in the *renaissance* of Hippocratism, from the sixteenth to the eighteenth century; and Bromfield even adds to the strictness of its precepts. Nearly all fractures, says he, are accompanied by contusion, and therefore by swelling; hence the first indication is to dissipate this swelling, either

* Laugier, *Bulletin Chirurg.*, tome ii, p. 253.

† See the *Gazette Médicale*, 1840, p. 552; *Bulletin Chir.* of M. Laugier, *loc. cit.;* and my *Journal de Chirurgie*, tome i, p. 441.

by general or by local means. For this, eight or ten days may suffice; but if a longer time is required, reduction should not be attempted till after the entire disappearance of the swelling; and "though I have sometimes been obliged," says he, "to defer it for more than three weeks, the callus has presented no obstacle, and the consolidation has afterwards proceeded as perfectly as possible."

Lastly, in our own day, two different lines of practice have been extolled. On the one hand, Boyer and Larrey, advocates in general of immediate reduction, agree still in admitting two great contra-indications, viz., when the irritated muscles are affected with spasmodic contractions; and when swelling, tension and pain denote a considerable degree of inflammation. On the other hand, according to M. Velpeau, neither inflammation nor spasm should induce any delay; so far from that, immediate reduction is the quickest and surest method of alleviating them.

The first question suggested by a statement so absolute is this: Is reduction always possible? In 1839, a coachman aged 30 sustained, while drunk, an oblique fracture of the leg. I saw him twelve hours afterwards; the fragments of the tibia overlapped one another, and all the muscles of the leg were in a state of such violent contraction as to place reduction out of the question. Two bleedings, a rigid diet, and the administration of forty centigrammes [about four grains] of opium per diem, altered the state of things so that on the fourth day the contractions had ceased, and the coaptation was easily accomplished.

This was a striking example of muscular spasm, which is rarely seen so strongly developed. Inflammation is far more common; and I do not hesitate to say that, however slight it may be, it renders reduction of a fracture of the arm or forearm impossible by the hands of assistants alone. In a case of overlapping fracture of the forearm, with active inflammation, I treated the latter by topical remedies, rest and compression, for five days; after which, the swelling having almost entirely gone down, I attempted reduction. I employed assistants, two on each side, but all my efforts were fruitless. Quite recently, at the second day of a fracture of the thigh, I found three aids, with loops, unable to bring the limb to its normal length. And it was only because reduction was impossible, that MM. Meynier, Laugier and Bérard had recourse to section of the resisting muscles.

I have tried to discover to what degree inflammation augments the muscular resistance. In a rabbit whose thigh I had broken, the shortening being one centimètre, a weight of one kilogramme, by means of a double inclined plane, sufficed to give the limb its natural length, or in other words, to lengthen the shortened muscles by one centimètre. Two days after, a weight of three kilogrammes produced a lengthening of only five millimètres.

In another rabbit whose leg I had broken, the experiment was at once more precise and more complete. I fastened in the tibia before the fracture two iron pins, eight centimètres apart; the first overlapping, which had amounted to two centimètres, was obviated by a weight of only 125 grammes. Two days afterwards, the shortening was the same; and a weight of five kilogrammes only lengthened the limb to seven and two-thirds centimètres. The twelfth day, there was still the same amount of overlapping; the fragments were still movable; a weight of five kilogrammes had no effect. With nine and one-half kilogrammes, I procured a lengthening of five millimètres. I went on successively to twelve, fifteen and twenty kilogrammes, without gaining more than one centimètre. Lastly, I tried twenty-five kilogrammes with no better success; and then the tibia broke with the weight below the lower pin, which prevented my going any further. Thus on the twelfth day I failed in the reduction, with a force two hundred times that which was sufficient on the first day, and about twelve times as much as the weight of the animal itself.

From these facts and experiments, it may be concluded that in some cases either muscular spasm or inflammation may render reduction impossible.

But apart from the chances of failure, will such attempts be harmless? Hippocrates observed that, whatever their result might be, they always tended to excite inflammation; it will be seen that this tendency is owing to the more or less irritated state of the parts, and to the violence employed. I once attempted, with the aid of assistants only, the reduction of a fracture of the cervix humeri, before the subsidence of the inflammation; I failed, but there was developed around the lower fragment an amount of suppuration which destroyed the patient's life. I have seen also, in two hospitals in Paris, two nearly similar cases. The patient, in whom M. Laugier divided the tendo Achillis for a fracture of the leg, had abscesses not only at the point of section, but around the fragments. In two of those operated on by M. A. Bérard, abscesses formed not at the seat of the division, but at the fracture; and in all these three cases the issue was a fatal one. Now may we not justly charge this to the attempts made at reduction during the inflammatory stage? And if any serious complication, such as a rupture of the integuments, is present to aggravate either inflammation or muscular spasm, it is not only suppuration which ensues, but gangrene; Boyer gives a striking example of this. "A young, strong, and robust man," says he, "in whom, after sufficiently enlarging the wound, I practised this reduction for a fracture of the femur, the upper fragment being stripped of periosteum for about two inches and a half, and protruding through the torn skin and muscles, did at first very well; and I was pleased with the success of the efforts I had had to make in effecting the reduc-

tion; but on the third day, inflammation of the limb came on, the tension became excessive, the swelling enormous; and the gangrene which supervened, in spite of all the resources of art, progressed so rapidly that it soon invaded the trunk and carried off the patient."

[Dr. Pancoast has recently put in practice, in the Pennsylvania Hospital, the plan of sawing off the protruding ends of the bones, in two cases analogous to those now under discussion. One was the humerus of a boy ten or twelve years old, broken at the lower epiphyseal junction; the other involved both bones of the forearm of a man, who refused to submit to amputation. In both these cases the result is extremely satisfactory.]

At other times, and especially when one has had to contend with muscular spasm, reduction may be followed by convulsions, delirium and even tetanus. Hippocrates has noted that in luxations of the ankle, which nearly always involve fractures, attempts at reduction made during the period of inflammation are more apt to induce convulsions when they succeed, than when they fail; and when the convulsions come on after reduction, he adds, there is little hope of saving life. Sir A. Cooper gives two observations justifying this melancholy prognosis. In a man who had fracture of the fibula with luxation inward of the tibia, reduction was effected by main force in spite of the spasmodic contraction of the muscles. On the next day the limb was affected with constant spasm; on the fourth day delirium also set in, and on the eighth death closed the scene. In another case tetanus appeared some days after reduction, and likewise carried off the patient.

I say nothing of the danger of tearing muscles, vessels and nerves, which is doubtless a rare accident in reducing fractures; it seems however that a misfortune of this kind happened to Boyer himself. He had a fracture of the thigh to reduce in a vigorous subject, and did not succeed; he redoubled his efforts, and at last gained his end; but at the same time a large vessel was opened, giving rise to such frightful hemorrhage that the patient died under the hands of this great surgeon.*

In fine, the two great contra-indications admitted by Larrey and Boyer, are only too well borne out by experience; and it will doubtless be readily agreed also that reduction should not be attempted without proper means both of effecting and of maintaining it. The only rational course then is, to put the limb in the most favorable position possible, and to combat the spasmodic irritation or the inflammation by appropriate means.

This course is however open to some objections which must be answered. Will not waiting too long give rise to the double danger

* Roux, *Disc. d'ouverture; Gaz. des Hôpitaux*, 1844, p. 535.

of the callus forming with the fragments in bad position, and of obliging nature to begin again, perhaps too late, all the work already done being useless? Clinical observation triumphantly obviates these timid objections. Thus it is known that any considerable inflammation always of itself delays the reparative process; and we have elsewhere established that, consolidation being divided pretty accurately into three stages, the organization of the callus does not begin until the second. One may, therefore, if the case call for it, fearlessly allow the first period to elapse before proceeding to reduction.

Another danger: will not the bony fragments, thus left to themselves in the midst of the muscles, determine the suppuration which it is so important to avoid? This objection, I do not hesitate to say, is purely theoretical, and contradicted by the experience of all ages. In fractures, with overlapping, of the clavicle, humerus, femur, forearm and leg, we hardly ever obtain perfectly accurate reduction; and yet suppuration is excessively rare. I have not for my own part seen it occur at the seat of a simple fracture, except in just those cases in which the inflammation had been aggravated by improper attempts at reduction.

Need we now discuss the question of the days, as proposed by Hippocrates? It is certain that the first day is generally the most favorable, and the second much less so. I have, however, cited one case in which reduction was impossible twelve hours after the fracture; and Galen, criticising Hippocrates, justly remarks that if inflammation is absent, reduction may be as properly attempted on the third or fourth, as on the first or second day. On the other hand, the seventh day is very far from being a certain limit to the duration of the inflammation; but Hippocrates has given the true rule in such cases, viz., to wait for the inflammation to subside before attempting reduction.

§ V.—*Of Apparatus.*

When a fracture occurs without displacement, or after this latter has been overcome by the process of reduction, it is necessary to keep the fragments at perfect rest in their proper place, until consolidation occurs; and this is the object of our apparatus.

The forms of apparatus contrived for treating fractures in general may be arranged under six heads, viz., (1) *ordinary splints;* (2) *immovable apparatus;* (3) *plaster apparatus;* (4) *leather belts, straps, etc.;* (5) *hyponarthecia;* (6) *apparatus for permanent extension.*

(1.) *Ordinary Apparatus* or *Splints.*—Following the chronological order in the exposition of this subject, we have first to speak of the apparatus used by Hippocrates; and we think they merit the more careful description, since they received the approval not only of all

antiquity, but also of the principal surgeons of the sixteenth and seventeenth centuries.

Hippocrates employed two forms of apparatus, one provisional and the other permanent. The former he applied at the outset; first covering the limb with cerate, he took a short bandage, and placing one end over the seat of fracture, made two or three turns loosely, so as not to cause too much pressure; thence he carried the bandage to the upper part of the limb, where it should end. A second roller, somewhat longer, was likewise applied, beginning at the seat of fracture, and going downward by wide spiral turns to the lower end of the limb, then again upward, passing by its own commencement, and ending where the first did. The direction in which these bandages were made to run varied with the nature of the displacement. If the fragments inclined toward the left, the turns were applied from left to right, and *vice versâ*, so as to press the fragments in the opposite direction.

These first portions of the apparatus received the name of *hypodesmides*, or under-bandages. They were again covered by long compresses spread with cerate, arranged, as well as we can judge, parallel to the axis of the limb. In case of great diminution in the size of the limb toward its extremity, as in the forearm and leg, these compresses were carefully graduated so as to make the thickness the same throughout. The whole was finally made firm by two more bandages, *epidesmata*, one of which passed from left to right, the other from right to left; they surrounded the whole limb from below upward, except only some turns which had necessarily to pass downward.

This apparatus was renewed every three days, an additional bandage being applied at each dressing, the number of bandages, however, not being allowed to exceed six.

Lastly, on the seventh day, or whenever the inflammation had entirely gone down, the splints, constituting the permanent dressing, were applied. These splints, probably composed of flat pieces hollowed in the middle, were put on over the preceding bandages, one, thicker than the rest, being on the side toward which the fragments projected; they were to be of less extent than the bandages themselves; thus for a fracture at the middle of the leg, they were not to go beyond, or perhaps even to reach, the malleoli or the condyles of the tibia. It appears that their number was quite considerable; according to Paulus Ægineta, there should be an interval of a finger's-breadth between them, so that they should make a sort of frame around the limb. They were held in place by very loose bands, so as not to add to the pressure already exercised by the bandages; in the treatise "*De Laqueis*" of Oribasius, may be found a representation of a forearm thus surrounded by splints, in which the latter

are held together by a quite complicated knot called the "sailor's knot."

If now we inquire what views led Hippocrates to the employment of this apparatus, we find no other use for the cerate spread over the limb and over the compresses, than to make the bandages hold better; it was only an agglutinative. As to the bandages, the object of the first was to press away the blood from the seat of fracture, driving it back toward the upper part of the limb; the second, toward the lower part; and it was in order better to attain this end that the first few turns were made just at the seat of fracture, and that the pressure, stronger at that point, diminished upward and downward. It would seem that Hippocrates attributed to them likewise some agency in keeping the fragments in place. The compresses which came next, answered to our padding, insuring to the whole limb the pressure of the splints; the outer bandages retained the compresses in place, and the splints formed a sort of external skeleton to the limb. The apparatus actually in use for fractures of the humerus represents very well that devised by Hippocrates, except that the cerate is discarded as valueless; but one bandage, or at most two, are employed, and importance is no longer attached to the mode of putting them on; the only indications we seek to fulfil are, to establish an entirely equable pressure on the limb, and to fix firmly the compresses and splints.

In dressing fractures attended with a wound or with necrosis, Hippocrates used the many-tailed bandage of Scultetus.

The Arabians introduced two important modifications in splints. Rhazes recommended the use of shorter ones than those of the ancients: "There are cases," says he, "in which the reduction cannot be well maintained but with smaller splints, which fit the shape of the limb." He, however, supported these splints by others of the ordinary length.

Avicenna adopted the small splints of Rhazes; but elongated, on the contrary, the outer ones. In the arm, for example, he applied four splints, to go beyond the shoulder and elbow; for the thigh he used two, strong, wide, and somewhat concave, extending from the pelvis to beyond the foot. These large splints had one real advantage, in keeping the foot in a proper direction; they were however far from being generally adopted. After Avicenna, I do not find that they are recommended until the eighteenth century; then first by Duverney, and later by Desault and Boyer, who finally reintroduced them into ordinary practice. By reason of their breadth and length, they cannot be adapted to the shape of the limb, and hence some paddings are required to fill the interspaces. Avicenna recommended for this purpose cushions, *pulvini*, of the exact nature of which we are not informed; Duverney used compresses, and napkins folded lengthwise; Desault seems to have been the first to use the

bags stuffed with oat-bran, so generally employed at the present day.

It was doubtless the difficulty of procuring both the splints and their padding which led to the substitution of straw-compresses,* answering the same purpose at a much less expense. Guy de Chauliac attributes them to a certain Maître Pierre, who made them of long straws sewed up in a linen covering; A. Paré put a strong stick of wood in the middle, to make them firmer; and finally, in the eighteenth century, the linen envelope was done away with, and the straws simply bound together with a string. J. L. Petit preferred the compresses of Maître Pierre, the diameter of which was as much as two inches; Larrey adopted the straw tied up with a string; A. Richter describes them as made in the same way, but with a willow-stick in the middle; and in this latter form I have seen them still employed in Poland.†

Finally, whether with the large splints or with the straw-compresses, the bandages of Hippocrates and his mode of applying them were, generally speaking, retained. J. L. Petit and Duverney likewise recommended the placing of the first turns at the seat of fracture; only the theoretical object was changed; it was now to *retain the nutritious juice* and prevent deformity of the callus. But such an object could not be seriously aimed at; hence for the multiple bandages of Hippocrates were substituted first one of sufficient length, or even that of Scultetus; afterwards the bandage came to be commenced at the lower extremity of the limb; and from the time of Pott this was, in England at least, the usual practice.

But at the same time there commenced in the application of the bandages an innovation much more important, and one which, gradually gaining ground, has in our time reached its utmost extent. Until the eighteenth century the bandage never surpassed the length of the fractured bone, hardly even reaching to its extremities. J. L. Petit was the first to bring a turn of the bandage down from the forearm over the hand, and from the leg over the heel; but he made no change in reference to other fractures. Duverney bandaged the upper part of the forearm with the arm; and in the forearm he likewise took in both the hand and the arm. Boyer went further, and in all fractures of the upper extremity made the bandage extend to the roots of the fingers; while, curiously enough, he limited himself in fractures of the leg to a mere loop under the foot, and in fractures of the thigh did not go below the knee. Lastly Larrey, going beyond all these, enveloped each finger in a narrow bandage, for the

* [This article having passed entirely out of use, no English word remains for it except the compound one employed above. The French term is *fanon*. Our *junk-bag* seems to correspond most nearly to it.]

† For a more complete account of straw-compresses, see my edition of A. Paré, tome ii, p. 288.

upper extremity, and even in fractures of the cervix femoris, never omitted extending the bandage over the whole lower extremity.

It would be entirely useless and out of place to describe here the mode of application of the roller, the bandage of Scultetus, or the eighteen-tailed bandage sometimes made use of; these are elementary points as essential to the dressing of wounds as to the treatment of fractures. I shall likewise abstain here from detail as to the application of splints and compresses, which belong more appropriately to the history of each particular fracture. A more general and important question should alone arrest our attention; to wit, what is their real utility.

Boyer has attempted to show that the bandages intended to envelope the limb *serve infinitely little, if at all, to maintain the fragments in their natural position.* Suppose, says he, a roller applied for a fracture of the humerus or of the femur, all the turns surrounding each fragment are useless to prevent displacement; it is only those which are placed at the very seat of fracture, and hence act upon both the broken ends, which can serve to keep them in contact. Now to form an estimate of their inefficiency, it need only be observed that, allowing the bandage a width of three inches, an inch and a half only would bear on each fragment; and that this power, so much the more feeble from the substance of the bandage being soft, flexible and unresisting, acts only through the thickness of the soft parts, hindering it from reaching the bone. The eighteen-tailed bandage is as inefficient as the roller, and the bandage of Scultetus perhaps even more so.

This demonstration is not unanswerable; every bandage compressing the muscles circularly against the bone lessens to a certain degree the amount of separation of the fragments; and when long compresses are added, applied parallel to the axis of the limb, J. L. Petit goes so far as to say that they afford all the necessary support, and may even supersede splints. It may also be shown that a bandage, regularly applied to the broken arm of a dead body, gives the limb a notable degree of firmness.

Boyer, therefore, has gone too far, or rather has omitted the most serious objection to bandages. This is, that practically, whatever may be the efficiency of their pressure at first, they become relaxed in the course of twenty-four hours, and all their good effect is lost; and I think no surgeon would venture, on the authority of J. L. Petit, to rely exclusively on compresses. Slight as may be the tendency to lateral displacement, splints are indispensable; but if splints are sufficient for this end, it remains to decide what is then the utility of bandages.

Boyer answers that they are *very useful, whether to retain the necessary topical applications, to prevent œdematous infiltration of*

the limb, or lastly to soothe the irritability of the muscles by their pressure, warning the patient, so to speak, not to contract them. Such assertions hardly deserve a serious refutation. As for topical remedies, it is evidently easier to apply them to a naked limb than to one surrounded by compresses and bandages; as to œdema, bandages, with their circular pressure, are much more likely to determine than to prevent it; and the other use attributed to them, of allaying muscular irritability, is so much the more problematical since at the end of twenty-four hours, as has just been stated, their pressure ceases entirely.

Hence then, circular bandages alone cannot suffice for maintaining the fragments in place; and when splints are added to them, they become perfectly useless. Moreover, they have more than one injurious effect; applied to an inflamed limb, their relaxation is not always in proportion to the swelling, and then they exert a dangerous pressure, which may bring on gangrene; aside from this danger, they conceal from the surgeon the state of things, which it is so much his interest to watch; if they cover only the upper part of the limb they become a cause of œdema, if they extend its whole length they favor stiffening of the joints.

I know of but one case indicating their employment; it is when we need to protect the limb from the pressure of splints, using them as a sort of padding. With large splints, as in the lower limb, bags of oat-bran are infinitely more convenient; small splints, on the contrary, such as are applied to the arm, press too strongly on the skin, unless this is protected by a bandage. But even then the bandages need not extend beyond the length of the splints; this would be much more injurious than useful. In regard to this, I will merely repeat that from Hippocrates to Desault, inclusive, the lower portions of the limbs have been always left uncovered, and that Boyer himself, so careful to wrap the forearm and hand in fractures of the humerus, found no inconvenience in following the old plan in fractures of the femur.

All the efficiency of the apparatus we shall study being thus concentrated in the splints, let us see what conditions these should fulfil. Splints vary in respect to their composition, form, length, number and mode of application.

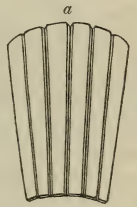
The splints of the ancients were made of sticks or pieces of wood, hollowed along the middle; those of the Arabians, of Alcona wood, of olive, pomegranate, palm, fir, or willow-wood. Guy de Chauliac speaks of splints of horn, of leather and of iron; A. Paré employed wood, lead, tin, prepared leather, pasteboard and bark; Bromfield recommended whalebone; and Boyer indifferently wood, pasteboard and tin.

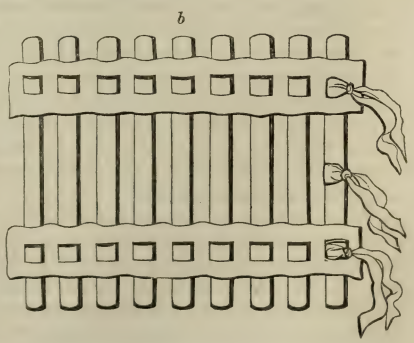
The essential object of splints is to restore to the limb the solidity

lost by the fracture, to replace as it were the internal skeleton by an external one. Hence the first quality requisite is a sufficient degree of firmness; but this firmness should vary with that of the bone in question, and according to the volume of the limb to be supported. Thus, in very young children, all fractures, even those of the thigh and leg, can be treated with pasteboard splints. In youth, pasteboard is hardly suitable for fractures even of the arm and forearm, and must be very thick, or else double; in adult age, its use is limited to fractures of the phalanges.

The arm and forearm, however, short and not thick members, do not require very heavy support. Splints of light wood, such as linden, poplar, and especially fir, are generally sufficient, although oak and beech are preferable for very muscular persons. These hard and firm woods are required only for the large splints intended for the thigh and leg; and it is necessary to give even them sufficient thickness to prevent their bending. On the whole, pasteboard and wood, which are common and cheap materials, easily obtained and worked into the required form, appear to fulfil all the indications; splints of leather, horn, whalebone, or metal, are of no special value; and bark is useful at most only in cases of necessity, and where nothing else can be had.

[Very excellent *immediate* or auxiliary splints may be made by splitting a piece of some light wood into slips from six to ten or twelve inches long, one-quarter to one-half of an inch thick, and three-quarters of an inch to an inch wide; these slips being then either glued side by side upon a piece of soft buckskin, as seen at *a*; or fastened together by means of two strips of buckskin, as shown at *b*. It is evident that more protection will be necessary for the patient's skin in the use of this latter form of splint. The number, size and length of the slips should of course be varied according to the size and length of the limb, and in using the second form we should employ a firm bandage from the toes or fingers upward, that the venous circulation may not be impeded.]





The *form* of splints varies little. They are always smooth, flat strips, rounded at the ends. Hippocrates put one stronger than the rest opposite the projection of the fragments; Guy de Chauliac advises that they should be thicker in the middle than at either extremity, so as to cause a greater pressure. But where such pressure is necessary, the thickening of the splints, or a special splint thicker than the rest, would be insufficient; and compresses arranged within ordinary splints have the advantage of making the pressure at once more exactly and more gently. Boyer recommends making the small splints light and flexible, in order that they may adapt themselves to the shape of the limb; and to have those of tin slightly bent, so as to fit the convexity of the parts. This adjustment is almost impossible to obtain in wooden splints, without depriving them of all solidity; and besides that the tin splints are not very convenient to use, their bending is necessarily uniform, and cannot be adapted either to the form of different limbs, or to that of the same limb in different persons, nor lastly to that of the different aspects of the same limb; compresses or padding with ordinary splints will equalise the pressure much better. We have stated that Avicenna hollowed out a slight channel in his large splints for the lower limbs; but experience has shown that flat splints, with junk-bags, answer the purpose much better.

There is perhaps but one exception to be made in this respect, in favor of pasteboard splints. When these are moistened before being applied, they become soft, and adapt themselves exactly to all points of the surface of the limb; and when dried they preserve this form, while returning to their original solidity; unlike the uniform bending of the tin splint, this is a perfect moulding upon the limb itself and upon each of its faces. Only, in making use of this material, the wetting of the apparatus customary with some surgeons must be avoided, as lessening its solidity.

The *length* of the splints deserves serious attention. There are four different lengths, to wit: (1) the small splints of Rhazes, adopted by Dupuytren under the name of *immediate splints*, much shorter than the diaphysis itself; (2) the splints of Hippocrates, reaching from one end of the diaphysis to the other, but not covering the epiphyses; (3) the ordinary splints of Avicenna, exceeding the length of the fractured bone each way; (4) lastly, the large splints of the same author, intended for the lower extremity only, and called by Dupuytren *mediate splints*.

The immediate splints are intended to press on the fragments just at the seat of injury, and to obviate all lateral displacement. It may be seen, indeed, that splints exceeding the length of the bone would bear on the projecting epiphyses, and thus be too much raised from the shaft of the bone to exert upon it a uniform and sufficient pressure; even those of Hippocrates, extending just over the diaphysis,

would not act upon the fracture if this occupied the most concave part of the bone. One might then substitute for immediate splints compresses of the same length, upon which the large splints should press; but to act on the convexity of a bone, as, for instance, on the anterior face of the femur, the large splints press too much at the centre, and too little at the ends; so that immediate splints become indispensable. But we must not forget that there is a special indication, in the absence of which they are useless; they answer very well to obviate transverse displacement; not so well in angular; still less in case of overlapping, and nothing or next to nothing in case of rotation.

The splints of Hippocrates and the ordinary splints of Avicenna, which are less efficient in lateral displacements, are much more so in the angular; but it is important to know which of them to choose; or, in other words, whether the injured bone only is to be made immovable, or the neighboring joints also. The answer to this inquiry cannot be the same in all cases. When an articulation cannot be left free without risk of deranging the fracture, it must be fixed by lengthening the splints; as, for instance, in fractures of the phalanges; and so also in all fractures close to joints. If this danger does not exist, as in most fractures of the forearm, we may be contented with splints the length of the diaphyses, or at most, reaching from one joint to the other.

[From a consideration of the extreme difficulty of preserving the muscles of any broken limb at perfect rest, and of the fact that so many of the muscles extend over two joints, as well as from the results of experience, the general rule may be laid down that *the limb should be well supported from its extremity as far up at least as the joint next above the fracture.* Most English and American surgeons, we think, adhere to this line of practice.]

Lastly, the *mediate* splints, designed almost exclusively for the lower extremity, to press on the foot from side to side, oppose rotary displacement as well as lateral flexion.

From these considerations it follows that each sort of splint has its special office; that our choice is to be guided by special indications; and that while in many cases all the splints used should be of the same length, there are often also cases requiring at once several splints of different lengths.

The *number* of splints is not less important. There is never occasion for more than two mediate splints, provided, however, that the plane on which the limb rests is supported by a surface answering the purpose of a posterior splint, and hindering all flexion either anteriorly or posteriorly. Boyer, I think, first advised the putting of another along the whole anterior face of the limb; but he gives no reason for it, and I really can discover none. The immediate splints should always be at least two in number, so as to give mutual sup-

port; to confine the bone on all sides, there is rarely need of more than four. It is so also with ordinary splints. Usually these are applied parallel, one on one side and the other on the other, always avoiding pressure upon the course of the principal vessels, so as not to hinder the circulation in the limb.

No splint should be applied to the naked skin. Pasteboard may be put on over a simple bandage; for immediate, or ordinary splints, it is necessary to have long compresses, sometimes graduated, or carded cotton, charpie, or wool; Guy de Chauliac used felt. I have already stated what sort of padding is required for mediate splints. The object of these interposed substances is not only to mitigate the pressure of the splints, but also to render it more equable, by filling up the depressions and hollows of the limb.

Besides these general rules, the custom has prevailed of enveloping the mediate splints in a separate piece of linen, called by Desault *drap-fanon*, [splint-cloth,] and by Boyer *porte-attelles*. This is a cloth of about the same length as the splints, and broad enough to cover the posterior part of the limb, and enwrap each splint three or four times. Hence the limb lies entirely in the cloth, which forms a trough, and acts as a sort of posterior splint. This trough would really exist if the splints were wrapped with the posterior face of the cloth, so as to let the belly of the cloth hang from the upper edge of each splint; but as they are wrapped with its anterior face, this advantage, at any rate problematical, is almost entirely lost, and on the whole the splint-cloth only serves to prevent the splints from slipping forward; an end which could certainly be attained with much less trouble.

[In the New York Hospital, the splint-cloth is discarded in fractures of the thigh, and the practice is to employ three strips of wide bandage, each of which passes completely round each splint, and is tied like the ordinary confining strips. This plan not only saves a vast amount of time and trouble, (as any one will testify who has had half-a-dozen fractured thighs under treatment at once,) but when either strip becomes relaxed, it may be adjusted without taking off the apparatus, or disturbing the limb in any way.]

When pasteboard splints are used, they are covered with what remains of the bandage, so as to be entirely concealed by the turns of the roller. Ordinary splints may be retained in place by the same means; or perhaps with bands made of ribbon about an inch wide, knotted on the external or on the anterior splint, and drawn tight enough to confine the fracture, without, however, causing any pain. I would remark here that the bands are as apt to become loose above as beneath the splints, and that the ribbons will, if too narrow, sometimes press painfully on parts unprotected by the splints. An excellent means of constriction, which I have often employed, consists of

two or three strips of adhesive plaster, varying in width according to the requirements of the case, and long enough to go round the limb once and a half or twice. They are not liable to become relaxed; when the limb emaciates, they may be tightened up as easily as ribbons; and lastly, the same strips may be used throughout the treatment.

There must be added here a few words on the subject of straw-compresses, since some surgeons still use them. Desault especially opposed them violently; he accused them of sliding backward and forward, thus leaving the leg unsupported and the foot free to fall outward. In this respect, we would say that they support the limb as well as the large splints, when there is no tendency to displacement; if this tendency does exist, either one would be insufficient, and the use of immediate splints becomes necessary. As to their slipping backward and forward, they will do so if not thick enough, but so also will splints, if too narrow. Thick compresses, and wide splints, are equally free from this fault. Moreover, the straw-compresses as prepared by J. L. Petit, of long straws and without rods, two inches thick, and not very firm, so as to flatten and mould themselves to the limb, are less likely to slip than splints. We prefer, however, the latter, as being more solid, and as by the bran-bags their pressure is rendered at once softer and more exact; but where the surgeon cannot obtain splints, the straw-compresses afford him a resource of no small value.

(2.) *Immovable Apparatus.*—By this we mean bandages surrounding the limb, and saturated with a liquid by means of which they acquire when dried a great degree of solidity. Their general denomination is therefore not derived from their composition, but from the rule adopted by their partisans of allowing them to remain until consolidation is complete.

We find a kind of glue, made with gum or starch, recommended by Hippocrates for fractures of the nose, and by Celsus for fractures of the jaw. But it appears from a passage in Rhazes, that it was an Arabian surgeon named Albugerig who extended the plan to fractures generally. Later, Albucasis employed cakes of tow steeped in a glue made of meal and albumen; lastly, albumen alone was used by the followers of the Arabians; by some with tow, and by others with bandages. These albuminated apparatuses were transmitted from age to age, and we find them described by A. Paré, Fabricius of Acquapendente, Wiseman, Cheselden, Moscati and Larrey. It should be observed, however, that splints were always used in addition; Wiseman and Cheselden appear to have first recognised the fact that when the apparatus dried the splints became useless. In our own times, in 1834, M. Seutin substituted starch for albumen; M. Velpeau, in 1837, dextrine for starch; M. Laugier, in 1838,

paper for the compresses; not to speak of other insignificant modifications.*

We have now to discuss, first, the nature of the solidifying mixtures, and afterwards the composition and mode of application of the bandage.

A solution of gum may be made in cold, but much more quickly in boiling water; it is very little used at present, although in case of necessity it answers very well in place of other substances. In order to make use of the whites of eggs, they are tempered and beaten up with water, so as to mix them with it as thoroughly as possible; Larrey added a solution of camphor in brandy, and lead-water; but these are useless, and may as well be omitted. The glue from starch is obtained by boiling; it is merely a jelly. The solution of dextrine may be variously prepared. Generally we begin by putting in a vessel a suitable quantity of dextrine, viz., about 500 grammes [about one and one-third pounds Troy] for a fracture of the thigh; 200 for the leg, and the same for a fracture of the arm or forearm. We pour upon this alcohol or camphorated brandy, and work the mixture until it has acquired the consistence of honey; this done, we add a sufficient quantity of hot water; and after one or two minutes' shaking, the solution is ready for use. According to M. F. d'Arcet, the proportions most favorable at once to the drying and solidifying of the apparatus are, 100 parts dextrine, 60 of camphorated brandy, and 50 of water.†

The mode of application varies, but this variation depends much less on the nature of the solution employed than on the particular views of each surgeon.

Larrey commenced by laying along the fractured limb some narrow compresses, dipped in the liquid; afterwards he enveloped the whole in an eighteen-tailed bandage similarly prepared, beginning with the lowest turns. Above this bandage were placed, according to the requirements of the case, the paddings, consisting generally of cushions or wads of tow; these being in place, the apparatus was

* H. Larrey, *Traitement des fract. des membres par l'appareil inamovible;* Thèse inaug., Paris, 1832; Seutin, *Du bandage amidonné, ou Recueil de toutes les pièces composées sur ce bandage*, etc., Bruxelles, 1840; Velpeau, *Note sur un nouveau perfect. de l'appareil inamovible; Bulletin de Thérapeutique*, Fév., 1838; Aguilhon, *Mém. sur le trait. des fract. par l'appar. inamov. en papier amidonné de M. Laugier; Gazette Médicale*, Octob., 1838.

† As regards dextrine, an important point was recently brought practically under my notice, viz., that as sold in the shops, it is often unfit for making an agglutinative mixture; it forms lumps with alcohol, as starch does with cold water, without cohering; and twice in succession I have been obliged to change the supply at the Hôpital Saint Antoine. The dextrine thus deteriorated is whiter and less saccharine; it crepitates more in the fingers; and on pouring a few drops of tincture of iodine into the solution, there is produced a violet tint, indicating the presence of fecula; while true dextrine, treated with iodine, gives a vinous red, or the color of onion-peel.

freely moistened with the remainder of the solution. Lastly came the bran-bags, the straw-compresses wrapped in their cloth, and the bands to keep all in place. These compresses were kept applied as long as the bandage itself.

M. Seutin makes his apparatus of separate bands and compresses, as in the so-called bandage of Scultetus; sometimes with rollers, and lastly with pasteboard splints. These latter are straight or bent, according to the appearance and form of the part; torn rather than cut, so that their edges may be more yielding; having openings, likewise torn, corresponding to the osseous prominences; and are either passed quickly through hot water, or held some minutes in cold, to make them supple. What distinguishes M. Seutin's method particularly, is that he does not soak his apparatus; he lays on the glue above it, with a brush or with the hand. Thus he begins by covering the limb, dry, with a layer of bandage or of compresses, and over this he spreads the mixture with the brush or hand; the next layer of bandage thus becomes smeared on the inside in being put on, and is again spread with the jelly on its outer surface. At this stage the osseous prominences are protected by covering them with wadding, charpie, "cat-tail"-down, agaric, etc.; over this are applied the pasteboard splints, themselves in turn smeared with the mixture; they are kept in place by new compresses and bandages, and finally the last envelope is thoroughly starched. Thirty or forty hours are required for complete drying. In order, meanwhile, to keep the fragments in good position, M. Seutin adds a provisional apparatus, preferring an old mould from a previously cured fracture.

M. Velpeau prefers rollers to all other forms of bandage, and soaks them beforehand. M. F. d'Arcet has contrived for this purpose a little vessel like a dyer's vat; but this has been discarded, and the bandages are unrolled and rolled with the fingers, just as usual. The limb being previously entirely enveloped in a dry roller, its hollows filled with compresses, the bandage smeared with dextrine is applied spirally from the extremity of the limb up to the trunk, as if for the purpose of compression, but avoiding reverses as much as possible; this roller being exhausted, the external surface is smeared with what remains of the solution, the hand being passed from above downward or from below upward, according as the spirals run. There is thus but one bandage used, and no splints of any kind. Sometimes, however, M. Velpeau adds pasteboard splints; quite commonly, also, he puts on wooden splints provisionally, on the outside, removing them after complete desiccation has occurred. This latter may be hastened by suspending the limb from a hoop, by two or three bands smeared with cerate to prevent their becoming glued to the apparatus.

Lastly, M. Laugier, as has been said, uses neither compresses nor bandages; he employs instead *tarred* paper (*papier goudronné*,) which

is found in the shops in the form of thin but solid sheets, sixty-five by ninety centimètres; his glue is composed of starch. The paper is cut into strips, four or five centimètres wide, by forty-five to sixty long, so as to go at least once and a half round the limb; the longest serve to envelope the foot or hand, and to increase the firmness of the apparatus, by holding together others longitudinally disposed. In all, we must have strips enough to make, each one being covered in three-fourths of its width, four complete envelopes to the limb. They are first arranged upon a pillow protected by a cloth, and smeared with the paste on both sides. Those for the upper part of the limb are first applied, and covered successively by the lower ones; over this first layer is applied the second, then the third, then the fourth, each layer being carefully strengthened by longitudinal strips, as was before said. It is very important to lose no time when the strips are once soaked, lest the paper, becoming too moist, should give way in the surgeon's hands. In summer-time, twelve hours are enough for the drying of the apparatus; in winter it takes twenty-four hours, and it is well then also to put along the sides of the limb hot bricks, or stone bottles full of boiling water. Meanwhile, the limb should be so placed that its direction cannot change, and the patient should avoid making the slightest movement. M. Laugier sometimes applies also provisional splints; and lastly, he prevents the foot from falling over by means of a sling, the ends of which are fastened above to the hoop.

We see that MM. Seutin and Velpeau take care to cover the skin with a layer of dry bandage or compresses, to protect it from the injurious contact of the dried apparatus. If the limb is large and fleshy, this may suffice; if there are very marked osseous prominences, it is well to cover them specially with wadding or agaric; but when the limb is thin and the skin delicate, I take care to increase the number of dry compresses; and I have discovered the usefulness also of the precaution of Hugues de Lucques, who in fractures of the leg, for instance, covered the knee with dry tow or linen, to avoid the pressure of the upper edge of the apparatus. These dry compresses serve also to absorb the cutaneous transpiration, and to prevent the contact of the adhesive matter with the skin. M. Laugier omits this precaution; it would seem, however, that some of his patients suffered from uneasiness, and that on removing the apparatus the skin was found reddened, or even excoriated. Larrey, so far from keeping the limb dry, moistened the apparatus, during the first few days, either with his albuminous mixture, or with camphorated vinegar and water; but we must note the difference between these liquids, the latter being really an evaporating lotion, and employed as such by Larrey, with the object of cooling the limb.

The apparatus, once in place, is generally left to itself; but here the practice of M. Seutin differs essentially from that of others.

From the second to the fourth day, and much sooner if he feels at all uneasy as to the state of the limb, M. Seutin opens his apparatus from above downward, so as to be able to separate the two halves like valves; using very strong blunt-pointed scissors or shears. This section made, if the apparatus fulfils the indications, it is reapplied with a starched bandage. If it is too tight, it is enlarged by leaving a suitable space between the edges, to be filled up by a small slip of pasteboard, moistened and fitted on the skin; if there is too much pressure anywhere, by an irregular turn of the bandage, or by a wrong arrangement of the pasteboard, the apparatus is softened at that point with hot water, the bandage or splint set right, and a delicate layer of wadding applied over the skin; the state of the parts is daily examined, until they may safely be left to themselves. If afterwards the apparatus becomes too large, a longitudinal strip is cut away, and the edges of the section brought together. In any of these cases, a roller, starched and applied externally, renews the firmness of the apparatus.

This danger of the apparatus becoming too large, from diminution of the swelling in the soft parts or from atrophy of the limb, is common to all these forms of treatment, and has engaged the attention of all their adherents. Larrey merely advises tightening the bands above the compresses; but M. Velpeau prefers renewing the bandages throughout, which is doubtless the safer plan. As to some other propositions, such as to pour in plaster between the splints and the limb, to fill up the interspaces, it would probably be superfluous to mention them.

But the solid nature of these moulds in which we envelope the limb, makes it necessary to describe the mode of removing them. There is in this respect a great difference among the liquids employed. Diluted albumen, although giving a bandage solidity enough, adheres less than jelly or dextrine, and usually allows of stripping off the compresses one after the other. It is but seldom, except when dried pus has contributed to harden the bandage, that one is obliged to cut it from one end to the other. The shears of M. Seutin are extremely convenient for this; Larrey used ordinary strong scissors, dividing layer by layer, and always carefully avoiding any shock or jerk to the limb. Starch is more resisting; and in order to strip off the bandages stiffened with it, it is necessary to moisten them with hot water. But dextrine is still more obstinate; the least attempt to separate the layers breaks them almost like glass, and the limb must be subjected to a complete and long-continued soaking.

If now we examine the mode of action of these different forms of apparatus, it is in the first place evident that before drying they can only act like ordinary bandages, and hence can avail nothing in maintaining reduction. We must therefore, during one or two days, make use of some other means for this, such as the compresses of

Larrey, the moulds of M. Seutin, the provisional splints of MM. Velpeau and Laugier. Once solidified, all these external applications become useless, and M. Seutin has justly discarded them. But are his pasteboard splints really necessary? Before the drying, they are moist, and of course without firmness; after it, they are superfluous. M. Velpeau has therefore happily simplified the apparatus by omitting them.

But if the immovable apparatuses derive all their efficiency, before their drying, from external supports, they cannot, after it, have any more efficiency than these had; for in drying they acquire only the capacity of replacing them. Now these compresses, these splints, these hardened moulds, extended along the limb, may indeed prevent angular or rotary displacement, but can avail nothing against tranverse displacement or overlapping; which is true also of our ordinary immovable apparatuses. Nor is this all; they hinder the rotation of the foot, in fractures of the thigh for instance, simply by holding the limb extended, and enveloping it down to the toes; and this is why Larrey, who carried his bandage only to the heel, was obliged to use straw-compresses during the whole of his treatment. So also, MM. Seutin, Velpeau, and Laugier, take in the whole of the lower extremity; and they even, but with less reason, carry their dressings down to the ends of the fingers in fractures of the upper extremity. I have already stated how much risk this mode of treatment involves of stiffening of the joints, and I shall have occasion more than once to recur to it.

This plan is open to other objections; as, for instance, that the apparatus exerts too much pressure at first, and afterwards becomes too large; and that, during the whole progress of the case, it conceals the state of the limb from the surgeon. These different points will be discussed to more purpose when we come to speak of the choice of an apparatus, and the times of applying and renewing it.

As to the comparative value of the different elements of these forms of apparatus, I employ either of the mixtures proposed that may be at hand; and so far have found no reason for any preference. The manner of soaking the bandages is not of much more importance. Lastly, the use of rollers is certainly preferable in fractures of the upper extremity; but for those of the lower, the bandage of Scultetus, or the compresses, have the incontestable advantage of being put on without disturbing the limb. Of the paper splints I have no more to say, except that they would afford a valuable resource in case of a scarcity of linen.

(3.) *Of the Plaster Apparatus.*—This form of apparatus dates as far back as the Arabians. Albugerig, the writer already spoken of, besides gum and rice-water, employed powdered chalk or calcined plaster; and another surgeon, called by Rhazes Athuriscus, mixed chalk and white of eggs, to obtain a more solid mortar. It appears

that this use of plaster was retained in the east; Eaton, an English consul at Bassora, about the close of the last century, writes that he saw a fracture of the leg cured in this manner, for which a European surgeon had proposed amputation. It seems that it was common in Upper Egypt at the time of the French expedition to that country, and Froriep attributed it to the Moors of Northern Africa. In Europe, I find it employed first by Hendriksz, at the hospital of Groningen, in 1814; some years later, by Hubenthal, who believed himself to be the inventor; but these attempts had been forgotten, when Keyl, having employed plaster at the Charity Hospital in Berlin, in 1828, succeeded at last in calling general attention to it.*

There are several modes of constructing this apparatus. Dieffenbach invented a peculiar box for running the plaster, which I have tried, but found very inconvenient. Besides, the necessity of using the hammer and chisel to break up the moulds when they are in one piece, involves shocks which might injure a recently consolidated callus. The simplest mode is that of Hubenthal; but the unsized paper employed by him answers no useful purpose.

He begins by rubbing the limb with warm oil, to prevent the hairs from sticking, and by covering the lower part of the limb with a paste made of equal parts of plaster and unsized paper, reduced to a mash with a sufficient quantity of water. Afterwards, having a trough of pasteboard held under the limb, he fills with the paste, at one gush, the entire space between the trough and the limb, so as to envelope half the thickness of the latter. This done, and before the paste has solidified, he scrapes with a knife or spatula the two edges of this lower half of the mould, thus making them entirely smooth; he also cuts several notches, so as more firmly to attach the upper half. These edges, with the notches, being oiled so as to prevent too firm an adhesion, he finishes by laying the paste over the upper half of the limb. The mould is thus formed of two halves, easily separated in case of need, exactly fitted to one another, and retained in place by bandages.

There is but one defect in this description. The mixture would run out at each end of the pasteboard trough, unless in some way prevented; hence it is well to surround the limb with a towel of sufficient thickness, above and below, and to make the pasteboard rest against these temporary barriers. Common cerate may also be substituted for the oil in the preparatory greasing.

* See *Med. Commentaries*, decade ii, vol. ix, p. 79; Seutin, *Du bandage amidonné*, etc., p. 17; Hubenthal, *Nouv. manière de traiter les fractures; Nouveau journal de méd.*, tome v, p. 210; Muttray, *De cruribus fractis gypso liquef. curandis;* Diss. inaug., Berlin, 1831; A. L. Richter, *Abhandlungen aus dem Gebiete der Praktischen Med. und Chirurgie*, Berlin, 1832. I have given an extract from these last two works in the *Gaz. Médicale*, 1832, p. 525; and 1833, p. 285.

The Arabian apparatus, as seen in use by Eaton, differed little from this; only there were placed in the lower half of the mould several hollow reeds, to favor the drying, and doubtless also to diminish the heat developed by the plaster. This precaution has been generally deemed superfluous. But in the upper half of the mould, the Arabian surgeon had made a channel along the spine of the tibia, so as to apply evaporating lotions, and also so as to have the fracture in sight during the treatment. Dieffenbach, who made his mould in one piece, nevertheless left uncovered part of the anterior surface of the leg; and A. Richter, adopting this modification while making his mould in two pieces, thus returned almost exactly to the Arabian method.

So far we have plainly shown the mode of applying the mass of plaster; but there are some essential points connected with its preparation.

The plaster used is the common pulverized. The white is preferable to the gray, which is mixed with foreign matters, and makes a less homogeneous mass. It should not be recently calcined, nor in too fine a powder, lest too great a heat should be generated in its solidification. To temper it, it should be put little by little in a proper quantity of spring water, with constant stirring. The mass is just right when it is of the consistence of thick cream, and there is no water on the surface. If the plaster be added in excess, it will not be sufficiently liquid, and will develope too much heat in setting; hence it is well to let a little of it run beforehand, by way of trial. Lastly, the whole quantity required must be mixed at once, a fresh mass not easily uniting with a portion already solidified; and it should be prepared at the very moment when it is to be used, as it sets quickly, and then loses its facility of adaptation to the limb.

The advantages of this apparatus, at the first glance, are striking; cheapness, easy application, permanence and solidity, equable pressure; besides which it allows of the fracture being always under observation, and of applying suitable topical remedies, without fear of its becoming disarranged or soiled.

But on further examination, it is found to be open to quite serious objections. In the first place, the weight of the apparatus, which must at least hinder it from being generally applied. This is, however, less of an inconvenience than it would at first seem. It has been feared that by preventing the slightest movement, the apparatus would greatly fatigue the patient; experience has completely done away with this idea. The surgeons of Berlin believed that the use of this method should be confined to fractures of the leg; but Hubenthal had previously treated in this way fractures of the forearm, of the hand, of the clavicle, and, in fine, every fracture but that of the leg, for which he had no opportunity.

We have already said that the plaster, in setting, developes a

pretty high heat. Muttray asserts that it is but slight, and that a larger quantity of plaster gives out less than a smaller. This latter assertion is contradicted by A. Richter; and for my own part, in a case in which I applied the plaster according to Dieffenbach's mode, in a single mass of considerable thickness, so intense a heat was developed that the patient, a stout and courageous man, complained much of it for several minutes. It must be, however, that there are variations in this respect, the cause of which is not well known; for M. Woillez, having plunged a thermometer in a vase containing a litre of fresh plaster, observed a very gradual rise of temperature during an hour, the greatest height not being as much as 14° Reaumur. [61° Fahr.]

Another and more serious objection is derived from the expansive force of the plaster, which in setting may compress the limb too tightly. Muttray says that this is hardly perceptible, and would have no bad result. M. Woillez adds that it takes place outward, and has even the effect of enlarging the mould; so that, he adds, in spite of the immobility of the limb, there is always a slight space left between the limb and the plaster, during the solidification of the latter; and of this he cites several cases. The same author, however, explains this phenomenon differently a little further on. The leg is held suspended by assistants while the plaster is running, and the calf is free; while afterwards, when the limb is left to its own weight, the calf is flattened out, leaving thus in front a considerable space. M. Woillez thought this space ought to be filled by pouring in fresh plaster; but on doing so the severe pains induced by the excessive pressure obliged him to break the mould. For my own part, in the patient before mentioned, who had a compound fracture of the leg, I applied the plaster on the eleventh day from the accident, the limb being in the most satisfactory condition. All the anterior part of the leg was left bare; I entirely covered the knee and the ankle. Next day, a slight but painful swelling involved the integuments along the edges of the plaster; I removed these edges, which seemed to exert too much pressure. The second day, the same thing occurred; ascribing it to the plaster around the knee, I removed the upper half of this. The third day, it was necessary to do the same by the ankle, and moreover, to hollow out with a chisel the sides of the mould, which were still too tight; and the same proceeding was called for on the ensuing days, till at last the mould was broken in pieces, and replaced by an albuminated apparatus. M. Woillez has seen a similar case; whence he concludes that the plaster cannot be borne by subjects who are very sensitive.* I think it important, therefore, at least in cases where there has been

* Woillez, *Obs. et Réflex. sur l'emploi du plâtre coulé; Gaz. Médicale*, 1836, p. 353.

some previous inflammation, to surround the limb with some folded compresses before applying the plaster; we thus avoid at once the immediate pressure and the excessive sensation of heat; and I have been satisfied with the results of this precaution.

A. Richter has also remarked that the prolonged retention of the limb in the mould, by confining the perspiration, makes the skin tender, and even causes superficial excoriations; for the prevention of this he advises moistening the limb with lead-water, and, after the fourth week, putting a compress between it and the mould. The smearing with oil or cerate, necessary in the ordinary methods, would tend to bring on such accidents; the interposition of compresses from the beginning, according to my plan, renders the smearing unnecessary, and has the advantage of obviating all the dangers at once.*

There have been, recently, other attempts at inventing petrifiable dressings, which seem based on those of the Arabians; thus for instance, M. Lafargue proposed to mix equal portions of plaster and of starch. Of these I have nothing special to say.

(5.) *Of Cuirasses.*—I embrace under this head all forms of apparatus intended to completely envelope the fractured limb.

Wiseman is the first author who mentions them; their use was then confined to fractures with wounds. Some, easily made extemporaneously, were formed of two troughs, a superior and an inferior, of pasteboard, copper, or tin, held together by three bands; others, kept on hand, were softly padded on the inside, and provided with an opening for the dressing of the wound. J. L. Petit saw such *cuirasses* employed; and Heister describes a copper one, composed of three pieces united by hinges, and held in place by bands. But all these attempts are small compared with the great machine of La Faye; it was made of tin, and was therefore light, but not costly; it consisted of longitudinal pieces joined together by hinges, so as to be laid flat beneath the limb; hence it was easy of application; it confined at once the pelvis, thigh, leg, and foot, hence it insured complete immobility; but it could if necessary be divided so as to make a special receptacle for the knee or leg, and hence was adapted to any fracture of the lower extremity. Lastly, La Faye would even adapt it to all patients, great or small; therefore for a short limb he made the pieces slide into one another; for a thin limb he made one part overlap the other, and had the bands tied tighter. There were still wanting openings for the dressing of wounds; Coutavoz added these, and then it would seem as if no room were left for improvement.†

The majority of the succeeding inventions were much inferior to

* A. Richter, *loc. cit.*

† *Mém. de l'Acad. de Chirurgie*, tome ii, p. 403 *et seq.*

this. The copper buskin of Ravaton is clumsy; the wooden splints of Gooch, glued to a leather band and fastened around the limb, are deficient in solidity. Lastly, quite recently, M. Bonnet of Lyons has had prepared, first in iron wire, and afterwards in pasteboard moulded on wooden mannikins and then strengthened with iron bands, a cuirass much more complete than that of La Faye. It envelopes not only one, but both legs, and not only the pelvis, but the trunk up to the armpits. Doubtless immobility is thus still more effectually secured; but the new apparatus, having only a single opening in front, is less easily applied than that of La Faye, cannot be so well adjusted on limbs of different lengths, and lastly is only suited to fractures of the femur. M. Bonnet himself confesses that *the majority of simple fractures of the leg or thigh are far from calling for its use.*

The upper extremity was much longer neglected by mechanicians. Ravaton however, conceived the idea of inclosing the arm in a copper cuirass called by him his *contentif;* and M. Bonnet has constructed another, far more complicated, enveloping at once half the thorax, the arm, forearm and hand. It should be added that the cuirass of the right side cannot be used for the left; and a special one is required for each patient, since it must be modeled on the exact shape of the body.*

When we seek to estimate the utility of these machines, we see at once that the simpler they are, the less they can rival those ordinary apparatuses which have as much or more efficiency; and that the more complicated they are, the less chance they have of being generally adopted in practice. The ingenious invention of La Faye has for a long time existed only in recollection. It would hardly then seem worth while to dwell upon the description of things consigned to oblivion. And yet when they have been called forth not merely for the convenience of the patient or the surgeon, but to fulfil some special indication, we should notice that this indication does not disappear with them. I cannot, for instance, perceive any other real advantage in the cuirasses of M. Bonnet, than that they fix the pelvis or the shoulder; but this is sometimes an essential point, recognised by others, and one to which we shall recur in connection with fractures of the humerus and femur.

(5.) *Of Hyponarthecic Apparatus.*—[This term, derived from ὑπο, *under*, and ναρθηξ, *a splint*, has no parallel word in English, and has therefore been merely Anglicised. Any form of apparatus whose main feature consists in its affording a bed for the injured limb, would come properly under this head.]—We come now to an-

* Bonnet, *Mém. sur les fractures du fémur*, etc.; *Gaz. Médicale*, Aug. and Sept., 1839; *Sur des appareils nouveaux*, etc.; *Bulletin de Thérapeutique*, tome xviii; and *Compte-rendu du Service Chir. de l'Hôtel-Dieu de Lyon*, Lyons, 1844, p. 26.

other form of dressings, in which at least half the limb is left exposed, or even the entire limb, all but the portion resting on the sustaining plane They are very various, comprising *troughs*, *boxes*, *cushions*, *slings*, *boards*, *double inclined planes*, and *fracture-beds;* and their history has hitherto remained one of the most confused departments of surgery.

Troughs date as far back as the time of Hippocrates; they were placed according to necessity under the leg, the thigh, and even under the pelvis; and some surgeons added to them the foot-board. They were at first made of wood; afterwards of clay; and although usually the limb was deposited in them only when enveloped in bandages and splints, Paulus Ægineta informs us that in fractures accompanied by wounds, some surgeons used them alone. A. Paré speaks of troughs for the upper extremity, made of lead, pasteboard and tin; and credits himself with the invention of a tin one for the leg. In the eighteenth century, Ravaton made them of wood, copper, and hammered iron, for fractures of the thigh and of the leg; the limb was retained in place in them by iron rings; but their use rendered that of any other apparatus unnecessary. Assalini, in 1812, advised making them of varnished tin, either for the thigh or for the leg, with straps and buckles to confine the limb. So far, all the troughs for the lower extremity were straight, so as to hold it extended; in 1825, Dr. Nathan Smith separated the trough for the leg from that for the thigh, jointing them at the knee so as to give the limb any degree of flexion which might be judged proper. M. Munaret contrived, in 1835, an analogous apparatus, with the addition of slinging it; he afterwards gave this up, returning to the simple suspended board. Lastly, M. Mayor has recently recommended one made of iron wire; I have seen also those of M. Cambrai, made of zinc; the material used is however of but slight importance.*

Boxes differ from troughs in consisting of a bottom joined to two flat parallel sides. Galen described one under the name of *glossocomum*, and says that it should be so narrow as when lined with wool to hold the limb quite firmly, allowing it no motion. But this plan soon fell into disuse; I find no more mention of it until it is spoken of by A. Paré, who calls the apparatus *quesses*. J. L. Petit describes the box in common use before his time as composed of a foot-board, a bottom and two sides; each of these was padded within, and they were so united by hinges as to be taken apart at will. But he himself, wishing to make this more complete, devised another, which constitutes an era in the history of this form of apparatus. First, instead of wood, the bottom was made of ticking stretched in

* N. Smith, *New York Med. and Phys. Journal*, Oct. and Dec., 1825; (quoted by A. Richter;) Munaret, *Lettres Chirurgicales à M. Mayor*, etc.; *Gaz. Médicale*, 1835, pp. 433 and 673; and *Du Médecin de Campagne*, Paris, 1837, tome ii, p. 78.

a frame, forming a sort of bed of webbing, which was prolonged under the thigh, and sloped here like a double inclined plane. Again, the whole box was jointed at the upper end to another frame resting on the bed, and the lower end could be raised up or let down on this frame by a kind of hook, so as to change at will the elevation of the limb. The fate of this box may well impress the observer; it was, according to Louis, the only invention of J. L. Petit's which found favor in the eyes of his enemies; and yet Louis, who himself calls it *excellent*, has to regret that it is *far too much neglected in practice*. It afterwards went more and more out of use, and at present it is almost forgotten.

This machine was plainly a combination of the box and the sling; while the box of James Rae, described by B. Bell, is in reality a sling. Boxes had been almost discarded in the treatment of fractures, until Förster reintroduced them for those of the leg, with an entirely original addition; and lastly, M. Baudens has recently made them the basis of his apparatus for all fractures of the lower extremity, and even for those of the forearm.

The peculiarity of Förster's apparatus lies in the use of wet sand, to fill the box and confine the limb. Besides the side-pieces and foot-board, the box should be closed above by another board to keep the sand in, having a semicircular opening to receive the ham. The box being half filled with the wet sand, the limb is placed in it, and then a sufficient quantity of sand is added to cover it to the level of the spine of the tibia, leaving the anterior surface of the leg open to view; the sand should be kept constantly moist.*

The boxes proposed by M. Baudens closely resemble the ordinary ones described by J. L. Petit, except that the bottom alone is covered with a hair pillow; the sides are each pierced with two parallel rows of holes, intended to allow the bands or loops for maintaining coaptation to pass out and be fastened on the outside. The foot-piece is likewise bored with holes for the passage of the extending loops; we shall speak again of these in connection with the special means used for this purpose.†

Cushions also are of ancient origin; Galen relates that some surgeons of his time, in place of a trough or box, merely laid the leg upon a cushion; bands arranged across this were knotted above the limb, so as to make all firm; and they thought that the limb could be thus supported steadily enough for the patient to be removed from one place to another. After Galen's time we must come down

* A. L. Richter has represented in his Atlas Förster's box, and also a modification of it by Kluge. See also, by the same author, *Abhandlungen aus dem Gebiete der Praktischen Med. und Chirurgie*, Berlin, 1832; and an extract from it, given by me in the *Gaz. Médicale*, 1833, p. 285.

† *Gazette des Hôpitaux*, from Aug. 22d to Oct. 29th, 1844.

to that of J. De Vigo, to see a fracture with an external wound treated by merely placing it on a bed of cotton and cloth, supporting this at the sides only by two round pieces of wood, and fastening it to the limb by transverse bands. But this was an exceptional case, while Pott made it a general rule to use cushions for retaining the limb in position. He however added the eighteen-tailed bandage, and splints in case of need. But we find, not long before our own time, Richerand and Dupuytren returning to the exclusive use of cushions, and treating fractures of the cervix femoris in this way; Dupuytren applying it even to fractures of the clavicle and cervix humeri.

Slings date no further back than the eighteenth century, and J. L. Petit's box may be considered as the first one tried. Perhaps the "strap-bed" devised by Ravaton for suspending his buskin, first suggested the idea of a sling made of separate girths, so as to make a kind of hanging bed for the leg. Posch published at Vienna, in 1774, a description of such a sling; some years later, B. Bell described another very similar to this, due to James Rae of Edinburgh. Subsequently, about the year 1800, Faust reproduced the flat-bottomed sling of J. L. Petit, but lengthened it for the purpose of suspension; and again Tober adopted the separate girths, but extended them so as to make them a substitute for the flat bottom. We should remark that thus far the sling had been used only for fractures of the leg; I know of no one before Delpech who thought of constructing a double inclined plane for the thigh, made of frames with separate girths stretched tightly across them. The bottom, then, may be in one or in several pieces, tense or lax; and here are at once four great divisions of slings, varying again according as they are made of leather straps, of girths, of ticking, etc. I have seen one with the bottom knit in one piece, said to have the advantage of better adapting itself to the shape of the limb; the name of its inventor has escaped me.

But the suspensory method has called forth other forms of slings. Those of Posch and of James Rae, modeled on the bed of Ravaton, had for their basis a board of sufficient length and breadth, placed flat on the patient's bed. From the four angles of this board rose four uprights, connected at a suitable height by four cross-pieces; and to the two longitudinal cross-pieces were attached the straps or girths, by buckles or stitches. But about 1791, Löffler having conceived the idea of a suspended platform, Braun combined with it the sling made of separate girths; his apparatus, of which I have amodel, was made of a board suspended by strings at the four corners; to this board was attached the sling, so as to hang beneath it. Faust applied the same mode of suspension to the simple sling; Tober attached the four cords to the four angles of a frame upon which the girths were stretched; lastly, Graefe adapted suspension to the

old apparatus of Posch. As for the rings, balances, pulleys, and gallows-frames, used to support the whole concern, I shall doubtless be excused for omitting their description.*

Boards (*planchettes*) are still more modern than slings. We have seen that J. L. Petit and Duverney placed boards beneath their cushions, as supplementary to the ordinary apparatus. Pott was still more bold in recommending, in some cases of fractured femur, the putting under the cushion instead of under the thigh a very wide splint, differing from the ordinary board only in being hollowed out. B. Bell substituted a board like this for James Rae's sling, for fractures of the leg; Löffler, going further, conceived the idea of suspending this board by four cords. By this means fractures of the leg may be treated by semiflexion, without the necessity of Pott's lateral decubitus. We want the same advantage for treating fractures of the thigh; we obtain it by using the double inclined plane. Thus, boards, inclined planes, suspension, all would seem complete; what more is needed? It remained to apply suspension to the inclined plane, and to adapt the suspended boards to fractures of the upper extremity; to counteract lateral displacements by means of handkerchiefs attached to the edges of the board; these objects were attained by Sauter of Constance, besides whom we must mention M. Mayor as having essentially simplified all these apparatuses.†

Setting aside these complications, there are still in use at present two great varieties of the *planchette;* the simple, and the suspended. To the simple board there pertain two very different modes of employment.

M. Jobert, for fractures of the lower extremity, contents himself with the large board proposed by J. L. Petit. He places under the mattress a board the size of the bed. No pillow is allowed, but a slender bolster supports the head, so that the entire trunk lies horizontally. The limb is placed on a cushion of oat-bran, which is of oblong shape, and pressed down in the middle by the surgeon; this cushion reaches from the heel to the thigh for fractures of the leg, and as far as the buttocks for those of the thigh. The limb is thus supported posteriorly and at the sides. A cloth, folded into a cravat and fastened to each side of the bed, passes across so as to prevent

* Posch, *Beschreibung einer neuen sehr bequemen Maschine, das Fussbett genannt*, etc., Wien, 1774; Metzler, *Beschreibung der Braun'schen Maschine*, etc., Ulm, 1800. I give these two principal references after A. L. Richter; for the other German surgeons quoted in the text, see his work and atlas. The double inclined plane of Delpech has been described and figured by M. Gerdy, *Traité des Bandages*, second ed., p. 408.

† Löffler, *Beiträge zur Arzneiwissenschaft und Wundarzneikunst*, Leipzig und Altona, 1791; Sauter, *Anweisung die Beinbrüche der Gliedmassen, der vorzüglich die complicirten und den Schenkelbeinhalsbruch*, etc., Constanz, 1812. (I quote these two authors after A. L. Richter.)

any anterior displacement. To this, when necessary, can be added continuous extension.*

M. Mayor's system, so far as confined to simple hyponarthecia, favors more Duverney's use of the board. This is in fact here entirely isolated from the bed. It should exceed by at least six or eight centimètres the normal length of the fractured limb, and by sixteen or eighteen its normal breadth. It is covered by a cushion of at least equal size, thick enough to prevent all painful pressure on the limb, and for this purpose stuffed with cotton, oat-bran, wool, tow, hay, straw, leaves, etc. This cushion we adapt to the shape of the limb, by hollowing it to correspond to the prominences, and thickening it by accumulating the stuffing where the parts are thin or need to be better supported; so as, in a word, to make a trough exactly fitting the posterior third of the limb. It is best, then, that the cushion should have a thickness of not less than from eight to thirteen centimètres, according to the nature of the stuffing and the size of the limb. To fix the limb, it generally suffices to pass around it at about the middle a very broad cravat, going also round the board, fastening them together and making them, as it were, one piece. If this does not answer, permanent extension may be made by means of two cravats placed round the extremities of the limb. If there still remains some lateral displacement, a cravat should be passed beneath the limb, and its ends both brought to the same side, so as to make the body of the cravat press on the projecting fragment and bring it into proper position. The two ends should be knotted at the other side of the board, to rings, holes, pegs, or nails, etc. However, after having long extolled the simplicity of this method, M. Mayor at last owns that it is *quite inconvenient and cumbersome, and takes a long time to get it in place.* But, he hastens to add, *all is simple and easy, if in place of a board we make use of a wire trough.* Lastly, in fractures of the leg and of the thigh, it is important to have at the lower end of the apparatus an upright like a ladder, for attaching the cravat which goes round the foot, and for sustaining the weight of the bedclothes.

Such is the simple hyponarthecia, which is still preferred by M. Gerdy for fractures of the leg.† But M. Mayor combines it in all cases with suspension. For this purpose he uses two cords, one of which, passing through four holes at the four corners of the board, or being fastened in some way to the four angles of the wire trough, should form two loops either laterally or crosswise; these loops being fixed to the other cord, which hangs vertically from the ceiling or from a frame over the bed. But here there occurs at once a serious difficulty. To cover up the limb so suspended, it is necessary that

* *Note sur un mode partic. de traitement des fractures; Bull. de Thérapeutique*, May, 1842.

† Gerdy, *Traité des bandages*, second ed., p. 424.

one edge of the sheet and other clothes should pass up to the vertical cord, and then be so disposed in folds as to fall over the whole apparatus; forming a sort of scaffolding, to be held together by means of pins. But however warm the air may be, neither leg can be well covered; and if the mass of covering be increased, the apparatus is rendered less movable. M. Mayor obviates this by putting upon the apparatus a small down-pillow or a piece of flannel, and covering it up something like a doll's bed.

Another difficulty is to know where to attach the vertical cord, when the bed has no frame above, or where the ceiling is too high; M. Mayor advises putting two uprights, one at the head and the other at the foot of the bed, with a cross-piece between them, and then attaching the cord to the gallows thus formed. To fix the cord in the loops, the simplest plan is this: we place at some distance (about sixty centimètres) from one end of the cord a buckle or ring, suitable for making a running noose. We now pass the end of the cord through the two loops, and through the ring or buckle above; and having hoisted the apparatus to the proper height, as by a pulley, we fasten the cord by a simple double knot, (the ordinary *carter's* or *packer's* knot.)

The *double inclined plane*, which is strictly nothing more than a combination of two boards, was of later invention. It appears that White, of Manchester, first conceived the idea; but he had a machine made of iron, adapted to the shape of the limb, and consequently too heavy and too complicated. James constructed one of wood, but hampered with sides so as to make its application still inconvenient. Sir A. Cooper, in 1798, separated the sides from the rest of the apparatus, so as to apply them or not, according to circumstances.* I shall merely mention the double inclined planes of Sir C. Bell, of Sauter, and of Delpech; describing that of Sir A. Cooper, my own, and lastly that of M. Mayor.

Cooper's double inclined plane is composed, first, of a wooden frame reaching from the tuber ischii to the heel. At the upper end of this frame is jointed to it the femoral plane, which itself is hinged to that for the leg; the lower end of the latter rests in a set of notches in the frame first mentioned, so that according to the notch used the flexion may be increased or lessened. Lastly, there is a foot-board running in a mortise cut in the leg-piece, so that it may always be placed in contact with the foot, whatever may be the length of the limb.

* *Surgical Works of A. Cooper and B. Travers*, translated into French by Bertrand, tome ii, p. 179, note. This note is not in the original treatise by Cooper. It should be added that the description which follows above is founded on the plate given by that author; according to the text, the lower frame is replaced by a board, and the hook by holes in which a peg is inserted so as to support the board on which the leg rests.

I myself make use of two boards hinged together, with a foot-piece at the end of the plane for the leg; each side of these two boards presents a raised edge, so as to prevent any slipping of the cushions. To maintain the degree of flexion required, there is only necessary a strap or a strong band passing from one plane to the other. Lastly, when the weight of the pelvis tilts the apparatus inward, my remedy is to nail beneath the plane for the leg a transverse bar, which insures the firmness and proper position of the whole.

M. Mayor's apparatus does not differ from the rest except in its greater width. It is intended to receive both lower limbs, fastening them together so that the sound one may serve as a kind of inner splint, and the sound foot afford a sure and easy means of fixing that of the injured side.

Singularly enough, and not less so from the number of analogous facts in the history of our art, M. Mayor, while announcing in 1841 what he doubtless considered as the last step toward perfection, found himself anticipated long before by the invention of fracture-beds.

Fracture-beds are to semiflexion what large cuirasses are to extension—a means of fixing the trunk; and it is perhaps not without interest to note that while the latter are of French origin, the former are due to English surgeons. Harrold appears to have first conceived the idea; Earle made some improvements on it; and lastly came Amesbury.

Amesbury's bed consists of a horizontal frame supporting three pieces of wood, or planes, hinged together, and long enough when connected for an adult to lie stretched out upon them. The upper plane, receiving the trunk, is naturally raised at the bolster-end; the middle one, intended for the thighs, is made of two pieces sliding on one another so as to suit limbs of different lengths, and forms with the third piece a double inclined plane; this last, which supports the legs, has a foot-piece, used to confine the feet when this is necessary, and always serving to sustain the weight of the bedclothes. The upper of these planes is supplied with a thick mattress; the two others, with similar ones only half as thick. The middle one has an opening with a basin fitted to it to receive the fœcal evacuations; and the pelvis is fixed by means of a belt passing across the upper of the three planes. Lastly, the hinges are movable, so that the different angles may be changed at will.

Now on inquiring into the value of hyponarthecic apparatuses, we see that their chief object is to maintain the position of the limb. Troughs form a solid plane of support, affording besides a certain degree of resistance to lateral displacement. Boxes, by means of their stuffing, are converted really into troughs; cushions are likewise changed, by being pressed down in the middle; slings, when hanging loose, are the same; slings when stretched firmly require

cushions, still hollowed into troughs; the same is true of boards, of double inclined planes, and lastly of fracture-beds. Whether the sides are more or less raised, or more or less solid, is of small importance; or rather if the sides are too high, as in boxes, they are really mischievous, by preventing the careful watching and arrangement of the limb. Suppose for instance a fracture of the thigh; lateral angular displacement is mainly induced by the pelvis slipping down on the sound side; now no one will say that the inner border of a trough, as deep as we usually suppose it to be, would make any firm resistance to this tendency. Even cuirasses do not completely suffice for this unless they surround the trunk and both limbs. Hippocrates himself brought the pretended advantages of troughs down to their proper estimate. "As to the question," says he, "whether or not a trough should be placed under the leg, it seems to me to be as yet undecided. They are doubtless useful, but not so much so as is thought. They do not hold the leg motionless, as some suppose; for when the rest of the body is turned to one side or the other, they do not hinder the leg from following the movement, unless the patient himself guards against it; nor do they any more prevent the leg from moving to one side or the other without the rest of the body. They are however of real use when the patient has his bed changed, or goes to stool."

If troughs give so imperfect an assurance against lateral angular displacements, do they not at least obviate angular displacements upward or downward? One would at first think so, since the limb rests on a solid plane. But this solid plane must be covered by a thick cushion; this cushion by and by gets out of shape, becoming thick here and thin there; and if the heel for instance sinks too low, the leg will make an angle forward at the seat of fracture. The thicker the cushion, the greater the risk of such an event; in other words, the limb is separated so much further by the padding from the solid plane, and the whole apparatus has so much the less solidity. We should therefore avoid having the cushions too thick; and as on the other hand if they are too thin they allow of too much pressure, we see the necessity of not trusting too much to the apparatus, but of constantly and carefully watching it.

Such being the case, every apparatus composed merely of cushions should be regarded with suspicion, and I would say the same of slings of all kinds. Slings made in one piece, whether loose or stretched, yield at last to the weight of the limb; those made in different pieces answer no indication, and seem invented only to increase the risk of displacement. The most ingenious of all these is undoubtedly that of Braun, who varies the height of each piece so as to fix exactly to the prominences of the calf and heel, and to the intermediate depression; but I think no prudent surgeon would commit a fracture of the leg to a support so movable.

Against displacements taking place laterally, the inefficiency of mere troughs is confessed by their warmest partisans. Hence Sauter and Mayor pretend to counteract them by means of their transverse cravats; and M. Baudens, with his bandages, merely follows them. But we may ask, do these cravats or bandages fulfil their object? This may be doubted when we consider how liable linen bands are to relaxation; and if the muscles act powerfully against their pressure, not only is the displacement not prevented, but I have seen excoriations and sloughs ensue.

What now is the value of suspension as applied to boards, troughs, etc.? Is it merely a source of relief to the patients, making their confinement to bed less irksome? or is it really, as M. Mayor thinks, an additional safeguard against displacement? This question merits serious attention; but it will be more suitably discussed when we come to inquire what motions may be permitted to the patient.

(6.) *Of Apparatuses for Permanent Extension.*—The forms of apparatus hitherto described, by maintaining the direction or pressing on the circumference of the limb, counteract more or less any angular, transverse or rotary displacement; but they avail very little if at all against obstinate overlapping, such as exists in oblique or multiple fractures; hence the necessity for permanent extension.

This necessity has been felt since the earliest times; thus Hippocrates describes an apparatus for fractures of the leg, and Galen another for those of the thigh. But it is especially since the middle of the eighteenth century that these apparatuses have multiplied so fast that the mere enumeration of them would be tiresome. But almost infinitely various as are their forms, they range themselves under three classes, according as they act by *traction*, by *distension*, or on the principle of the *lever*.

In the first, traction is made on the limb by means of loops, weights, windlasses, screws, or jacks.

The simplest plan for making permanent extension is to hold the limb by two loops, one fastened above to the head of the bed, the other below to its foot. I find no mention of this prior to the beginning of the eighteenth century; but then it had come into general use. Thus J. L. Petit, for counter-extension, passed a large tablecloth or a half sheet between the thighs, first on the sound side, and afterwards, to change the point of pressure, on the injured side. Two other loops were arranged, one above the knee, and the other above the malleoli, so as to be drawn upon alternately, and thus moderate the pain. This method is preferred even now by Velpeau, except that he puts the lower loop below the malleoli.

However, simple as this seems to be, it is not suited to all kinds of beds, and it obliges the patient to remain constantly in exactly the same place. Desault and Sauter therefore conceived the idea of fastening the loops to an apparatus independent of the bed, Desault

to a splint, Sauter to a board, (*planchette.*) The splint of Desault, simplified by his successors, was to be very strong, long enough to reach from the iliac crest to eleven centimètres [nearly four inches] beyond the foot; at each end it had a mortise and a notch. The counter-extending loop passed through the mortise, and was tied at the upper notch; the extending loop was similarly attached below. Sauter attached his loops either to rings fixed at the two ends of his board, or, in the lower limb, to a sort of foot-board which served at the same time to keep the foot in proper position. I tried to apply this mode of making extension to the thigh placed in semiflexion; and for this purpose I added to the board for the thigh two solid lateral uprights, thirty-two centimètres [about eleven inches] beyond the knee, each of them having at its free end an opening by which to fasten the two ends of the extending loops; but my attempt was unsuccessful.

An inconvenience common to all loops of linen, bandages, table-cloths, or cravats, is that they very readily stretch; it has been attempted to remedy this in two ways: first by substituting cords or leather straps; and afterwards, the knots still proving insecure, and the surgeon's hands not always being capable of making sufficient traction, recourse has been had to more powerful and more certain means.

Guy de Chauliac made extension by means of a leaden weight, attached to the foot by a cord passing over a pulley; M. Seutin suspends a weight of five or six kilogrammes to the extending loop, and an equal weight to that for counter-extension. Dr. Nathan Smith also used a weight to make extension on the thigh, semiflexed and placed in its trough; the cord was carried up over a bar fixed high enough to make it draw in the line of the axis of the femur.

The windlass is more powerful than the weight, and its use is of greater antiquity. Galen describes a very ingenious *glossocomum*, in which the counter-extending loops, passing over pulleys above and on each side of the box, came down to be coiled with the extending loops on a windlass placed below the whole. The windlass may be fitted to the foot of the bed, as by Coutavoz, or to any frame of sufficient solidity. J. L. Petit adapted a vertical windlass to his extension splint.* Schmidt applied the principle to the trough, simple or suspended; Posch to his sling; and Koppenstetter to the double inclined plane, even putting a windlass on each division of it.

Next to the windlass comes the screw, which may be applied in the same way, that is by a solid cross-piece at the lower end of any apparatus whatever; Boyer even made it work at the end of a long splint nearly similar to Desault's. [The screw is extensively used

* Thillaye, *Traité des bandages*, p. 258. J. L. Petit himself has written nothing concerning this apparatus.

in different forms in the United States. Dr. T. H. Bache, of Philadelphia, has ingeniously adapted it to the long splint for fracture of the thigh, so that it may be graduated to the size of the apparatus employed. It is of great value in making steady and controllable traction.] Under the same head comes the jack,* of which I really know but one adaptation, that of Bellocq.

The plan of *distension* does away with loops and cords; we make use of splints which keep the limb stretched either by their own elasticity, or by means of a screw. In the first of all known appliances for fracture of the leg, Hippocrates fastened two circular leather pads, one below the knee, and one above the ankle; each of these pads had on each side two pouches; into these pouches were thrust the ends of four rods of dogwood, which were bent in order to insert them, and which in straightening out tended to elongate the limb. Paracelsus replaced the leather pads by iron bands, stuffed, and with boxes for screws at the sides; for the dogwood-sticks he substituted steel rods, passing through the boxes and keeping the iron bands at the proper distance apart; then by screws, playing on the rods, this distance could be at will increased or diminished, and with it the elongation of the limb. We find something similar in the mechanical splint of Fabricius Hildanus, and in the contrivances of Gooch and Aitken, as figured by B. Bell.

Lastly, in the system of *leverage*, we make use of the joint below the fracture to obtain a lever of the first order, and separate the lower from the upper fragment. The double inclined plane especially acts in this way in fractures of the thigh; it is only needful for the femoral plane to go a little beyond the articulation of the knee; then in flexing the leg down to the board intended for it, the tibia becomes a lever of the first order, the fulcrum being at the upper end of this board; and the lower fragment of the femur is thus drawn up the plane. In fractures of the clavicle, Desault's pad answers as a fulcrum on which the humerus plays as a lever, to carry the external fragment outward.

Such are the means hitherto used to counteract muscular action and restore the limb to its proper length; and at first sight it would seem as though nothing more could be desired. But the very power of these means gives rise to other dangers; for, first of all, both for extension and counter-extension, we must have a double grasp of the limb, which causes pressure or constriction in proportion to the resisting force of the muscles. Thus for example, loops passed over the perineum, or fastened below the knee and above the malleoli, bear very hard on the skin, and rarely fail to cause acute pain, excoriations, blisters, or even sloughs. Again, even at such a cost, we

* [A species of hoisting machine, commonly used for raising blocks of stone, and having a ratchet, an iron wheel, a crank, etc.—*Dict. de l'Academie.*]

are not always certain of success. For instance, in the lower extremity, a band passed in the fold of the groin would have too oblique a direction to hold the pelvis properly; and the extending loop in some forms of apparatus, as in that of Desault, would exercise also an oblique traction, which might give rise to some deviation in the fragments, and which at all events would make additional force necessary. It has been a desideratum, therefore, to overcome these difficulties, and diminish these dangers. Thus, for counter-extension, Fabricius Hildanus applied against the perineum the thick and rounded border of his splint. Arnauld attained the same end by having in the middle of the bed a post wrapped in linen; in Bellocq's machine there was an analogous *point d'appui;* and in the *cuirass* of M. Bonnet also, the perineum is pressed upon by the upper ends of the two troughs for the two limbs. Nicolaï went further; while making counter-extension by means of two loops passed beneath the perineum, he added a splint for extension on the sound side, and made both splints reach to the armpits like crutches. Tober went further still; besides the two crutch-like splints in the axillæ, he had another made, of a similar shape, to press in the same way against the perineum.*

Others, confining themselves to loops or to padded straps, attach them to a girdle surrounding the pelvis and thighs, and having at each side a pocket to receive the end of the extension splint. In J. L. Petit's apparatus, as described by Thillaye, this girdle was of leather, and stuffed; in that of Piéropan, it was of iron, and shaped like a truss;† Desault used a simple folded napkin to afford a *point d'appui* to the splint. I shall say nothing of those who dispense with counter-extension, expecting the weight of the body to offer a sufficient resistance; I myself had this idea when I first employed the double inclined plane, but experience soon led me to abandon it.

The need of direct traction by the extending loops has likewise led to various inventions. I shall simply mention the very complicated machine of Bellocq, which, after all, consisted merely in two lateral splints connected below by a cross-piece, upon which worked a jack. Boyer attained the same end by adjusting a foot-piece at right angles to his mechanical splint. Marcellin Baumers, again, conceived the idea of putting within the outer splint another, to reach not quite up to the level of the groin, to be connected with the inside splint by an oblique loop, and to have no other object than that of supporting the cross-piece below.‡

As to the means of protecting the integuments from excessive

* See Richter's Atlas, tab. xiv and xix.

† Thillaye, *Traité des Bandages*, p. 261.

‡ Marcellin Baumers, *Mém. sur le bandage de Desault*, etc.; *Journal Général de Médecine*, 1805, tome xxiv, p. 29.

pressure by the extending loops, the list of these also is very long. The parts pressed on have been covered with cotton; pads, cushions, stuffed bands, have been used; Piéropan, unless I am mistaken, first conceived of the laced gaiter, of which a thousand modifications have been made. Nothing has answered the purpose. From experiments made a good while ago, I concluded that rabbit-skin, the hair being turned inward, preserves the integuments better than anything else; and that the danger of sloughing is also notably diminished by fastening the loops upon plates of zinc or of pasteboard applied over the padding.

It has been thought that the sort of bed furnished by the immovable apparatus, by distributing the pressure over wide surfaces, lessened its inconvenience. Thus M. Seutin modifies his apparatus as follows, for fractures of the femur which require permanent extension.

He applies over the first layer of dressing a strip of bandage of the width of two fingers, and retains it in place by a starched roller; the middle portion of this strip forms a loop below the sole of the foot; its ends reach to a little above the condyles of the femur, where the extension should take hold, and are then folded back on themselves. To vary the point at which the extension shall act, a second loop is made a little higher up than the first, but fastened in the same manner. But as these loops cannot be made use of until the apparatus is completely dry, the extension previous to that is made by a loop fixed above the malleoli and made tense by a weight of five or six kilogrammes [twelve or fifteen pounds;] a cloth passed around in the fold of the groin, carried up to the head of the bed, and then fixed by an equal weight, makes the counter-extension during the whole of the treatment.

M. Baudens, without adopting the immovable apparatus for the fracture itself, borrows from it this means of making extension. He envelopes the leg in a layer of wadding from the feet up to the knee, protecting especially the instep, the malleoli, and the condyles of the femur. Then he puts on a few turns round the foot, loosely; then arranges at each side of the sole of the foot, parallel to the axis of the leg, the loop or middle portion of a bandage about one mètre in length, fixing both by new turns around the foot. Now passing up to the knee with a very close spiral, he covers up the cotton and both these strips of bandage; arrived at the level of the upper edge of the patella, he places on each side of the knee another doubled strip of bandage, the loop of it being downward like those at the sole of the foot. These are fastened by several circular turns, after which their ends are doubled down, and fixed thus by several fresh turns. In this way we make two lateral loops at the foot, and two at the knee, through which to pass the cords for making extension. But as the roller will very soon become loosened,

it should be entirely covered with a thick solution of gum, (three parts of gum to one of water,) in order to make it firm.

Lastly, M. Velpeau thought that the immovable apparatus, once solidified, would of itself suffice for maintaining permanent extension; he therefore commences this extension, as has been said, by means of loops attached at the head and foot of the bed, removing them when the apparatus becomes dry.

From the material now passed in review, it would be easy to make up all the varieties of apparatus for permanent extension which I have thought it unnecessary to mention.* A more serious question is whether any of them fulfil all the indications, and which of them affords the greatest advantages and the least inconvenience in practice. It is necessary that the forces used should act as nearly as possible in the direction of the fractured bone; that the extension should be made as gradually, and yet as powerfully and steadily, as may be required; and lastly, that the pressure exerted on the limb should be so gentle and so diffused, as not to cause excoriations and sloughing. Any apparatus which will carry out these indications may be used to advantage; I unfortunately know of none which will always answer when we have to deal with powerful muscles. Boyer adds a final condition, viz., that the apparatus must not press upon the muscles which pass over the fracture, and the stretching of which is necessary, thus excluding the whole system of distension. It is by no means proved that mere compression is of so much importance; the reason why these forms of apparatus have so nearly gone out of use, is rather because they are more complex than many others without being more efficient. It would be much more dangerous to press on the belly of a muscle so as to bend it over the loop, as for example if the perineal band should slip outside of the tuber ischii, and tend to push outward and upward the adductor muscles of the thigh; this should be scrupulously guarded against. There are, moreover, two great indications, apart from the apparatus used, in regard to lessening muscular resistance: the first is to relax the muscles by position; the second, to soothe their irritability before attempting to stretch them. This last question will be treated of in the ensuing section.

§ VI.—*Of the Choice of Apparatus.*

After so extended an exposition, which is yet very far from complete, of so many forms of apparatus, each supported by good authority, we may readily understand that the surgeon is at once met by the difficulty of making a proper choice. We say, first of

* The reader might consult on this point, besides the authors already quoted, two Theses of the Concours for fellowships in the Faculté of Paris; the first by M. Robert, 1832; the other by M. H. Larrey, 1835.

all, that this almost infinite diversity of means to one and the same end, is perfectly explained by two general facts, viz.: that some fractures are so simple, that they may be perfectly cured by any method, and with any apparatus; and that others are so obstinate as to set at defiance more or less all the means at our command; so that, by not properly discriminating between different cases, each inventor of a new system has always been led to extol his own success, and to contrast it with the failure of others.

Should a fracture occur without displacement, the bone being kept in position by the one collateral to it, as in cases of serrated fracture of the tibia or fibula, bandages, splints, immovable apparatuses, hyponarthecic apparatuses, slings, or even simple cushions, any of these will succeed, any of them will be suitable, the simplest or the most complicated; the only rule for the surgeon to observe is to discard whatever is plainly useless. In a word, there is here only the most elementary indication for treating all solutions of continuity: *to keep the parts immovable.*

But if there is a displacement which tends to recur, a new indication presents itself: to preserve, as much as possible, the exact relation of the fragments. And this general indication divides itself into as many different ones as there are varieties of displacements. Angular displacement is generally overcome with ease; but mere cushions, or slings, do not afford sufficient support for the weight of the limb; a posterior plane is required, horizontal or inclined; and sometimes lateral pressure by splints, troughs, or boxes. Rotary displacement calls for something more; in fractures of the lower extremity, for instance, the foot must be kept up by means of an upright, or by a regular foot-piece. Transverse displacements are still more stubborn; we have to act on the projecting ends of the bone with immediate splints, or with the lateral cravats of Sauter and of Mayor; the former seem to me far superior to the others, although even they are not always sufficient. I say nothing of displacement by separation, which demands the use of special apparatus; and lastly, when there is obstinate overlapping, our only resource is permanent extension. The immovable apparatuses, if suitably supported during the period required for their drying, are very efficient against angular and rotary displacements, except when they become too large from the shrinking of the limb; but they are worthless against displacements in the thickness of the limb, and yet more so, in spite of the assertion of M. Velpeau, as a substitute for permanent extension.

So far, we have only considered the condition of the bones; but we must recollect that we act only on the bones through the thickness of the soft parts. The danger of firm and prolonged pressure in making permanent extension is known to every one; but though less in other forms of apparatus, it is quite as real. Thus circular constriction, a little too strongly made, may bring on œdema, without

causing excoriations; local pressure, especially over subcutaneous bony prominences, as the malleoli, heel, etc., may give rise to pain, and sometimes to sloughing; lastly, the limb, kept too long immovable, will be subject to articular stiffenings not easily remedied. Doubtless this all depends very often quite as much on the surgeon's negligence as on the apparatus employed; the best apparatus, if badly managed, may do harm, just as the worst may have its defects compensated by the skill with which it is used. But it is no less true that much depends in this respect on the apparatus; thus I have before said that, in using the plaster, or any immovable apparatus, it is a wise precaution to cover the skin first with a layer of dry bandage, and to pad with wadding or with agaric the points most subject to pressure. As to stiffening, and even anchylosis, it has been established that they more frequently ensue from extension than from semiflexion; but the immediate and most powerful cause is the too prolonged want of motion in the joints. Hence the propriety of a medium posture for all the articulations which must be kept at rest; hence the value of occasional passive motion, and the danger of circular bandages embracing the limb down to its extremity. The history of these bandages leads us to this curious result: that until Boyer's time no one covered up the forearm entirely for fractures of the arm, and that Boyer himself abstained from doing so in the leg; for my own part, returning again to the old practice, I have never seen œdema ensue in the parts left uncovered except when the bandage had been too tightly drawn. On the whole, whatever apparatus any one may select, it must fulfil a third indication: *to protect the member, as much as possible, from excoriation, sloughing, œdema, and anchylosis;* I will add a fourth, less important, to be sure, in simple than in compound fractures, but never to be neglected unless for some particular reason: the apparatus should leave the limb sufficiently exposed to *allow of any symptoms which may arise being seen at once.*

Lastly, besides the requirements of the fracture itself, the state of the patient should sometimes influence us in our choice of apparatus. Very young children will soil with urine any dressing placed on the thigh; we need for them, therefore, something easily and cheaply renewed; and it is well to cover any such application with waxed cloth, so as to keep it dry as long as possible. Insane or delirious patients need firmer means of restraint; for instance, M. Mayor, having an insane patient who would not keep her bed, could devise no better plan than to surround the limb with cotton and with compresses, so as to give it a nearly cylindrical form, and then to confine it by the two halves of a tin pipe, like a high boot; so that the patient could even walk without very great danger. The use of the strait-jacket would keep the most restless subject in bed; and the plaster-apparatus would answer the same end as M. Mayor's me-

tallic boot. But it is very rarely that we need such powerful means. I have found it a good plan, in a case of fracture of the leg where I had reason to fear the restlessness of the patient, to arrange the limb on a wide cushion, doubled up at the sides and supported by two strong splints, so as at once to confine the limb and leave its anterior surface exposed. Among the insane at Bicêtre, I used also lateral splints without any previous bandaging, having placed the whole limb on a double inclined plane, so as to fix the thigh and foot as well as the leg.

On the whole, in exceptional cases as well as in ordinary practice, the surgeon who becomes a partisan of any one apparatus exclusively, deprives himself, in my opinion, of valuable resources, and lays himself very much open to the charge of empiricism. As I have before said, the indications are the end, the apparatus merely the means. The indications always remain the same; the means may vary greatly. Hence, then, in the treatment of fractures as in all other therapeutics, the choice of apparatus is but of secondary importance; the great thing is to appreciate the indications.

§ VII.—*Of the proper Time for applying the Apparatus.*

First of all, it is important to establish an essential distinction between such apparatuses as merely serve to insure the proper position of the limb, as cushions, inclined planes, slings, etc., which vary according to circumstances, and must always be applied at once, and such as are intended to maintain the reduction, enveloping the limb more or less, and exerting compression or extension.

The question, so circumscribed, touches in many points that concerning the most favorable time for accomplishing the reduction; and it has received quite as various solutions. Hippocrates, in cases of fracture in the long bones, applied at first a compressory bandage, renewed every two days, waiting till from the seventh to the eleventh day before putting on the splints. This practice prevailed throughout the good old times; and we must come down to Paulus Ægineta before we find the *moderns*, as he calls them, putting on the permanent apparatus at once. The latter was still the practice of surgeons in the time of Rhazes, who criticises it severely. It succeeds, says he, when there is neither wound nor inflammatory action; but more commonly the premature compression brings on unfavorable symptoms. In spite of this authority, most of the Arabian school, with Hagues de Lucques at their head, adopted the immediate application. The sixteenth century again put in force the Hippocratic plan, but it lost favor once more in the eighteenth. Lastly, among the surgeons of our time who have adhered to the compressory apparatus, some, with Boyer, apply it from the very first day, but with the precaution of putting it on lightly, and removing it on the following

day; others, like Larrey and M. Velpeau, put it on at once for the entire period of treatment.

Each plan has some reasons in its favor. From not taking off the apparatus on the second day, says Boyer, the limb has been seen to mortify, the bandage becoming too tight by reason of the swelling of all the parts and impeding the circulation; and at this first removal, we generally find the limb swollen, tense, hard and painful. According to M. Velpeau, on the contrary, far from augmenting the pain, the apparatus soothes it; if there is only the swelling caused by sero-sanguineous extravasation, compression prevents the development of inflammation; if this latter already exists, compression will favor its resolution.

It would be hard to understand how such experienced observers could so differ in their results, if one did not remember, first, that there are some fractures for which one or the other practice may be followed indifferently; and again, that even in such as, being accompanied by swelling and inflammation, appear especially to demand the greatest care, compression has sometimes had the happiest results. But this cannot shut our eyes to its dangers, which M. Velpeau himself admits in a passage too remarkable not to be quoted: "Although compression, rightly made, constitutes a really heroic practice, I should warn you also that when employed unskilfully it may become the cause of more or less serious symptoms. Do not forget it; it is a valuable resource in surgery; but let me say this, it allows of no half-way."

In truth, other partisans of the immovable apparatus have made it one of their precepts not to draw the bandage too tight, and M. Laugier claims it as a merit of his paper apparatus that it does not exert pressure. But it is much less the active pressure exerted at the moment by the bandage which is injurious, than the secondary and in a manner passive pressure caused by the swelling of the limb. Apart from this, what could be milder than the ordinary compresses and bandages, which always become relaxed in less than twenty-four hours? And yet one cannot deny that these apparatuses, prematurely applied, have given rise to serious symptoms; there is no hospital where such instances have not been observed; and Dupuytren, alarmed at their frequency, established a general rule that every patient affected with fracture should be visited twelve hours after the apparatus was put on, and that this should be reapplied at the first indication of any excessive pressure.*

The immovable apparatus, of whatever kind, is no more exempt from this, than the rest. In a young girl with double fracture of the humerus, M. P. Meynier had applied the albuminated dressing; next day there appeared yellowish phlyctenæ and a livid color of the skin

* *Clinique de Dupuytren; Gaz. Médicale*, 1832, p. 853.

about the elbow; the apparatus was quickly removed, but so severe were the symptoms for several days, that the surgeon greatly feared the necessity of amputating the arm at the shoulder. M. Defer has seen gangrene ensue from the premature application of the starched bandage for a fracture of the humerus and for one of the patella; M. Blandin has seen fatal results from the same cause. And even when there was no danger of gangrene, we have all seen, in one of the most distinguished of our Russian brethren, Professor Doubovitzki, the sad effects of a starched bandage applied immediately after a fracture of the elbow. When the apparatus was renewed, on the twenty-fifth day, the flexors of the wrist and fingers were indurated, blended into a hard cartilaginoid mass with the surrounding cellular tissue; it was impossible to raise up a fold of the skin over them; the wrist and fingers were entirely paralysed. This induration gave place to obstinate retraction, for which the patient submitted to twenty-nine subcutaneous sections; with what result is well known.*

Moreover, no one denies these facts; only the partisans of the immovable apparatus declare that they are to be attributed to the bandage being badly applied. M. Velpeau is more liberal, acknowledging that even if it be well put on, it does not entirely do away with the danger; but "it is easy," he adds, "by carefully watching the coming on of the symptoms, examining the color of the skin, noting the appearance of phlyctenæ, etc., to know rightly when the apparatus should be removed." But besides that the immovable apparatus, extended over the whole length of the limb, leaves only the ends of the fingers or toes in sight, I fear that this so-called guarantee would only engage practitioners in a false security. I have particularly studied the manner in which gangrene comes on in cases of fracture; and often I have seen it developed locally, without pain, or any other notice either to the surgeon or his patient. M. Velpeau himself has reported a very remarkable instance of such an insidious onset of gangrene; one of his patients, in whom such symptoms were developed, nevertheless assured him that he felt very well, and thus gave him a confidence sadly disappointed by the result.

Thus then, rarely enough, but much to be dreaded, and often impossible to suspect beneath the bandages, gangrene may follow the immediate application of constricting apparatus. Call it the fault of the surgeon, that point may be questioned; it is of slight importance, if somehow or other it is well known that your principle has its dangers. I can understand, however, that one would run the risk, if no other way were open to him, or if he had some great interest in so doing; but it is this very interest which is wanting; the hypo-

* P. Meynier, *Observations*, etc.; *Gaz. Médicale*, 1832, p. 61; Defer, *Observations de gangrène*, etc.; *Gaz. Médicale*, 1839, p. 446; Blandin, *Discuss. à l'Acad. de Médecine*, Aug. 6, 1839; Doubovitzki, *Mémoire sur la section souscutanée*, etc.; *Annales de la chirurgie*, tome i, p. 129.

narthecic apparatus suffices to support the broken limb until all danger of inflammation is past; and if need be we may have recourse to lateral splints as I make use of them, namely, without any previous bandaging, and leaving a large portion of the limb exposed.

Could we not however apply an ordinary roller, or the bandage of Scultetus, carefully renewing it once or twice a day, as advised by Boyer and Dupuytren? There is no objection to this plan, except first that such bandages are entirely useless, and again that they may do harm by the disturbance of the limb necessary for their renewal.

I establish therefore as a general rule:

That in no fracture with swelling and inflammation, should any compressing apparatus, surrounding the limb, be applied until all danger from that source has subsided. [This rule has for many years been observed in the Pennsylvania Hospital, and with very successful results. Whatever the fracture may be, if there is any tendency to inflammation, the latter is the first object of attention; and for the first few days, the limb is examined carefully at least once in every twenty-four hours.]

Perhaps also it would be prudent to postpone such applications for some days even in the very simplest fractures, so as to allow of the effusion of coagulable lymph, and the development of the provisional tumor; in order that there may be the least possible danger of any defect or delay in the consolidation.

The question comes up still more seriously as to the apparatus for permanent extension. In oblique fractures of the femur, Desault made extension from the first day or two, and said that he effected cures without any shortening. Boyer on the contrary thought that it would cause irritation of the parts, and powerful spasmodic contractions of the muscles, if used at once; he preferred waiting seven or eight days until the irritation and spasm were allayed, and even longer if such symptoms continued beyond that time. Lastly, Léveillé, going still further, put forth the general rule that permanent extension should not be made till half the time required for consolidation had gone by; so that if the case required sixty days, he would wait until the thirtieth.

An important point to establish in solving this question, is that permanent extension, in oblique or multiple fractures, is permanent reduction; and hence amenable still more strictly to the laws of ordinary reduction. If we are called immediately after the accident, so that the fracture may be reduced without the employment of great force, we may hope to retain it also without danger; at least it will be safe to attempt it. But if the next day the muscles, contracted by inflammation, obstinately resist our efforts, it would be highly imprudent to struggle against them, whether to effect reduction, or to maintain that already effected. Hence the rule given by Léveillé is an extreme one; by waiting so long, we should often risk

finding the muscles confirmed in their shortening, and the callus so solidified as to oppose a new difficulty to the reduction. Boyer's advice is better; but he errs perhaps practically, in applying his apparatus for fracture of the thigh from the sixth to the ninth day. In a stout man, in whom I had employed permanent extension on the sixth day of a fracture of the thigh with about five centimètres overlapping, I was compelled to remove the apparatus after three days; the shortening had increased to eight centimètres. The limb being placed between two ordinary splints, and extension being slightly applied occasionally, I was much astonished at finding, on the twentieth or twenty-fifth day, a shortening of less than three centimètres. We see here how the forcible stretching, by irritating the muscles, had increased the shortening at first, and how subsequently the mere allaying of the muscular irritation by rest, favored elongation. On the whole, the callus hardly beginning to organise until after one-third of the time required for its complete consolidation, I think we risk nothing by waiting thus long before applying permanent extension; although if the muscular irritability subsides earlier than this, we need not waste time; nor should we be too hasty if it should last longer.*

§ VIII.—*Of the Time for removing the Apparatus.*

Surgeons have hardly agreed any better on this question than on the last one. The practice of Hippocrates was as follows: if coaptation were exact, if there were neither itching nor danger of ulceration, he would leave the apparatus in place until consolidation was completed; but if he had never so little doubt about the perfect position of the fragments, then, at or a little before the middle of the time during which the splints should remain on, he removed the whole apparatus, satisfied himself of the reduction being permanent, and reapplied the dressings as before. This method prevailed until the time of Paulus Ægineta; but then it fell into disuse; some, like Paulus himself, renewing the application more frequently; others, going to the opposite extreme, putting it on at the beginning, to take it off only at the end of the treatment.

Of these three plans, the first has hardly been put in practice except by some zealous Hippocratists of the sixteenth century; the other two, although quite opposite to one another, have always prevailed. Even in our own time, we have seen Boyer removing his dressings every five or six days so as to assure himself of the exact state of the fracture; while Larrey, applying his immovable apparatus in its purity, put it on on the first day only to take it off on the last.

* Malgaigne, *De l'extension continue dans les fractures*, etc.; *Gaz. Médicale*, 1836, p. 170.

These frequent renewals of Boyer's are really unjustifiable; and he himself shows their uselessness when he advises that the bandage should not be removed, in all, more than three times, if a roller has been employed. As I have said before, if the fracture is attended with severe symptoms, we should leave it exposed, and not hide it beneath an inclosing apparatus; if there is any danger of displacement, we should doubtless be advised of it, but at the proper time; when there is no such danger, I see no motive for deranging the apparatus and disturbing the position of the limb, and imitate Hippocrates in leaving it untouched until consolidation is complete.

If, on the other hand, it is asked why Larrey used his immovable apparatus, the reason alleged is the incontestable fact, that absolute immobility is the safest guarantee of a prompt consolidation. If however it be objected that we must assure ourselves that the fragments are in place, the answer is that if they are properly reduced, and the apparatus properly applied, there is no risk of their becoming disarranged. To those, lastly, who would suggest that with the swelling present for the first few days reduction might not have been very exact, it is replied that this is a matter for every surgeon to decide by his own experience.

Such answers certainly leave to the objections all their original force. There is no experience, however extended we may suppose it to have been, which would always enable us to say that the fragments, masked by the swollen state of the soft parts, were reduced; moreover it has been demonstrated that while inflammatory swelling exists reduction is impossible. And what shall we say of the changes which may take place in the state of the limb? Sometimes, the swelling disappearing, the fractured ends play upon one another; or perhaps the atrophy of the limb from inaction suffices of itself to leave a space between the bandage and the skin; I say nothing of cases in which the displacement occurs during the time required for the desiccation of the immovable apparatus, as I have described the means for preventing this; but it may occur, and not unfrequently does, at the very time of application of the dressings, when the first compresses and the first turns of the bandage conceal it from view. What mistakes there may be then in this portion of our art, commonly thought to be so far advanced! How many displacements may ensue, deforming the limb, if not crippling the patient, to the lasting reproach of the surgeon!

Thus, having long ago returned in this respect also to the practice of Hippocrates, I assert that there is a positive and pressing indication to examine the fracture before consolidation is complete; and the time which should elapse before this examination Hippocrates has stated as distinctly as possible, viz., about two-thirds of the period necessary for union. When we expose the limb at this time, if the fractured ends are found in perfect contact, the appa-

ratus is replaced as before, and the surgeon may justly feel safe; but if there is any displacement, he is in time to remedy it. I have therefore established this general rule:

In simple fractures, but with a tendency to displacement, the apparatus should be renewed at the time when the callus, although fairly organised, has not yet become ossified; that is to say, after about two-thirds of the time required for consolidation.

Generally we may, after this, leave the dressings undisturbed until the end of the treatment; but should the displacement give us any cause for anxiety, we should again renew them as often as may be thought proper; sacrificing the advantage of perfect rest to the no less urgent necessity, both to surgeon and patient, of avoiding deformity.

I have here discussed only the question of removing the apparatus at stated times; should the patient complain of any itching, or of pain, or should the surgeon suspect any still more serious condition, the examination should be made at once.

[The operation of bending the callus of a broken bone is one by no means free from pain, or even danger; and the longer the adjacent joints are kept at rest, the greater the pain and difficulty of making passive motion in them. Moreover, not only is the approach of gangrene oftentimes extremely insidious, but the repair of a fracture is materially favored by a sound and transpirable condition of the skin overlying it. From these considerations it may be seen that the advantages attending the frequent examination and redressing of broken limbs are very great; so great, as in the opinion of most surgeons to counterbalance the risk of disturbing the position of the fragments, which after all may be obviated by using due caution. *Constant and careful watching of the fracture from the outset*, has saved many a patient from permanent crippling.]

§ IX.—*Of the Movements which may be allowed to the Patient.*

When the upper extremity has sustained a fracture, we may generally allow the patient to sit up, without any bad result; although the movement communicated to a broken humerus in the act of walking has more than once delayed consolidation in that bone. In the lower extremity, on the contrary, confinement to bed has generally been considered necessary; but this is thought sufficient; and provided the patient does not leave his bed, he is allowed and even directed to use some motion.

Thus when he raises himself to go to stool, or to eat his meals, it would seem so simple a thing, that since the times of Guy de Chauliac it has been recommended to let a cord hang from the ceiling within reach of the patient, to aid his movements. It was only a few years ago that M. Bonnet of Lyons called attention to the

displacements which may ensue, and illustrated the point by experiment.

Having sawed the femur in a dead body, obliquely downward and forward, so that the upper fragment overlapped the lower, "If," says M. Bonnet, "the neck was flexed, the upper fragment of the femur was not at all moved. If the thorax was gently raised, the upper fragment descended and passed forward a little; but as soon as the flexion of the trunk became more marked, approaching to a right angle, the upper fragment of the femur took a direction toward the back of the thigh, and passed downward and forward more than an inch toward the knee, as well as a little outward. These displacements disappeared gradually, as the trunk was replaced in the horizontal position. If in bending the trunk the pelvis also was raised, the displacements were the same, but occurred to a greater degree."

And M. Bonnet adds: "*From these experiments one may well be convinced of the danger incurred in fractures of the thigh, if the pelvis be raised to allow of the bedpan being passed under the patient.*"* Moreover, he obtained analogous results in regard to fractures of the leg.

Such deductions are really startling; for in view of them we can hardly understand how a fracture of the femur can ever be consolidated. But the very extent of the result precluded full confidence in it; I therefore resolved to repeat the experiments under various circumstances, so as to find out where they were at fault,—to determine the proper amount of injurious effect from motions of the trunk,—and to seek to discover some remedy.

A body with the muscles relaxed being laid on the table, and the femur sawed as mentioned, I found at once that on raising the head and trunk, overlapping occurred to the extent of about three centimètres; but the limb being put on a double inclined plane, the overlapping did not exceed one centimètre. I observed besides two very curious phenomena; to wit, that in restoring the body to the horizontal posture the overlapping was diminished sensibly, but was not, as stated by M. Bonnet, completely effaced; and again, that if the trunk was inclined forward, the overlapping was likewise diminished.

Studying this experiment attentively in all its details, it is easy to see that in raising the trunk at first, the pelvis was made to work backward and forward on the tuberosities of the ischia; the cotyloid cavities being thus carried forward, we have here at once a cause of overlapping; but moreover, these tuberosities, meeting no obstacle, slipped down more or less toward the foot of the table; a second cause of overlapping. When the limb was on the double

* Bonnet, *Mém. cité, Gazette Médicale*, 1839, p. 520.

inclined plane, the femoral portion somewhat prevented this sliding of the pelvis; the overlapping was produced almost entirely by the first cause; hence it was much less in degree. And we may understand likewise that in bringing the trunk again into the horizontal position, the effect of the sliding still remains, and therefore the overlapping can only partially disappear. If during the experiment the pelvis was raised by an assistant, the overlapping varied according as he held it immovable or allowed it to yield to the weight of the body. Lastly, when the trunk was strongly inclined forward, it reacted in the opposite direction by its weight upon the ischiatic tuberosities, which now slid backward, drawing up the upper fragment.

If this be so, we could obviate the last cause of overlapping, the sliding of the pelvis, by means of a loop passed between the buttocks; and we might expect also that the action of the other cause, the to-and-fro movement of the pelvis, would be notably hindered in this way. In fact, by making counter-extension in the manner just mentioned, the trunk has been raised with the limb in all positions, without any observable degree of overlapping.

These results being placed beyond doubt, it nevertheless seemed to me that much more weight would be given them by repeating the experiment on the living subject and in an ordinary bed. I tried it first with a sound person; the two legs being equally extended, we should in case of overlapping see the heel, which here represents the upper fragment, descending.

I began by raising the head and the chest, telling the subject to keep perfectly passive, making no effort whatever; the heel actually descended, but much less than the upper fragment had in the dead body; and examining into the cause of this, we found that the hollow made in the mattress by the buttocks almost entirely prevented the slipping down of the pelvis.

I then asked the subject to raise himself by means of the cord, using the hand corresponding to the limb we were observing. There was a movement of the heel, but it was hardly pushed downward; and hence there would hardly have been any overlapping. The overlapping was a little more marked, by using the other hand, or both hands together; but it was still very slight; and it became nothing when the pelvis was held fast by a counter-extending loop.

Lastly, repeating these same processes with patients affected with oblique fractures of the thigh or of the leg, I have seen that all the movements of the trunk, and especially such as were voluntary, were communicated to the upper fragment, in extension as well as with the double inclined plane; but the overlapping was hardly sensible; and this is especially easy to observe in the leg, where any motion would be evident both to the sight and to the touch.

It follows from all these experiments that the danger is much less than stated by M. Bonnet, although still claiming serious attention. When we have to raise the body of a patient too feeble to help himself, the pelvis should be prevented from descending by an assistant, placing one hand in the fold of each groin; or better still, in every fracture where there is danger of overlapping, we may fix the pelvis by a cloth folded cravat-wise, passed under the perineum, and fastened by both ends to the head of the bed. When the patient is robust and can raise himself, we should recommend him to use in preference the hand corresponding to the broken limb. We may also derive advantage from a precaution advised by J. L. Petit, and subsequently by Boyer himself. This was to fasten at the foot of the bed a solid and firm board, upon which was nailed a block covered with a cushion or a small mattress. This block is one of the greatest possible comforts to the patient; it serves him to press against occasionally with the sound foot, so as to push himself up when he slides down in the bed, and to raise himself with the cord without fear of sliding down or overlapping.

Other motions of the trunk may likewise have an injurious influence; thus, says M. Bonnet, in a fracture of the right thigh any bending of the body toward the left would carry the upper fragment outward; any bending of it toward the right would carry it inward, and these displacements would be more or less marked in proportion to the extent of the lateral motions of the trunk. So also of rotary movements of the trunk; whenever one side of the pelvis is raised, that of the sound side for instance, unless the two fragments are closely united, the upper one partakes of the motion of the pelvis; the weight of the body acting in part upon it, and the pressure of the plane on which it lies pushing it toward the inner side of the thigh, it sustains a double displacement, rotary and angular. M. Bonnet remarks, however, that the displacement is greater if the whole pelvis is raised at once; and the case is the same, or nearly so, with the leg.

There is some truth in these remarks, but like the former, they are certainly exaggerated, Every day, indeed, we make patients with fractured thighs go through both lateral and rotary motions, when we raise the pelvis to pass the bedpan beneath them; and yet all these fractures unite more or less favorably under the use of ordinary apparatus. This is because the splints, pressing on both fragments, oppose a considerable obstacle to the effect of these movements of the trunk; the counter-extending loop, which hinders the pelvis from descending, is another safeguard quite as efficient; and although the cuirass, making at once both limbs and the trunk immovable, would be assuredly preferable in theory, practice has shown, and still shows us every day, that it may very well be dispensed with. It is important, however, that the patient should be warned to keep himself as

perfectly at rest as possible, especially during the first third or the first half of the time requisite for consolidation.

While M. Bonnet advocates absolute immobility, M. Mayor finds on the contrary that it is carried to an excess in the ordinary forms of apparatus; and insists strongly on the advantages of the suspended board. "Patients," says he, "as soon as they are placed on the suspended hyponarthecic apparatus, can execute without danger any movement parallel to the horizon, whatever may be the gravity and the complications of their fractures." And as proof of his assertion, he gives the following experiment.

"Break both bones of the leg of a skeleton, and lay them on a suspended board. Put the different fragments together as in coaptation, and see if these pieces, though in no way fastened to one another, will be in the least deranged by the various motions which you may impress on the board, and if you cannot turn it in all directions without disturbing the bones, which here represent a comminuted fracture."

This experiment cannot be really serious. That one may put thus on a board two isolated fragments, forming with it, according to M. Mayor's expression, one and the same piece, and that they will not move, I admit. But just attach the upper of two fragments, either to a fixed or immovable body like the pelvis or to a lever connected with the pelvis, like the femur, and you will see what changes of position will be induced by the lateral movements of the board!

Moreover, it is very different when these motions are made by an exterior force; we must ascertain whether or not the movements impressed on the trunk, raising it, inclining it to the right or left, or the movements which it executes of itself, involve greater derangement of a limb placed on a movable board, than of one placed on a firm apparatus. I have made some experiments in reference to this point, which it may be useful to relate.

I sawed obliquely through both bones of the leg in a dead body, a little above the middle, so that the upper fragment overlapped the lower. The leg being put upon a double inclined plane, the overlapping was notably augmented by raising the trunk forward to an angle of 45°; but when the leg was on a simple suspended board, the overlapping hardly increased at all; there was, however, a much more considerable relative movement of the fragments, by which they made an angle salient externally, the foot being carried inward.

I reduced the ends so that they mutually sustained each other, and overlapping was impossible. Raising the trunk in the manner before mentioned, the leg being sometimes on the double inclined plane and sometimes on the simple suspended board, the derangement was always greater in the latter case, and always occurred in the same direction as in the other experiment. This unlooked-for result demanded an inquiry into its cause, to find which it was not very diffi-

cult. The lifting of the trunk tends to push downward the upper fragment; with the fixed apparatus, this either over-rides freely the lower one, or merely transmits an impulse in that direction; but with the suspended board, the movement impressed on the upper fragment is transferred first to this board, which, being longer than it is wide, sways to the right or left according as the ham lies nearer to one or the other edge, and carries with it the lower fragment.

An exactly similar oblique section was made in the femur, and the limb placed sometimes on a fixed double inclined plane, sometimes on the same in suspension. But this time it was evident that the raising of the trunk induced less overlapping, and therefore less motion in the fracture, with the suspended than with the fixed apparatus. It was to no purpose that I varied the experiment, making the fragments now overlap and now oppose one another, or inclining the trunk to the right or to the left; the derangement was always less in case of suspension; and the apparatus induced no sensible deviation laterally, as did the simple leg-board.

I know, and was the first to perceive, the incompleteness of these experiments, and their need of clinical confirmation. Hitherto time and opportunity have been wanting for me to pursue these researches; I believe, however, that we are able to prove at least conditionally, (1) that suspension lessens the danger from movements of the trunk in fractures of the femur; (2) that in fractures of the leg, the simple suspended board has perceptible disadvantages, and should be replaced by the double inclined plane.

Some surgeons, however, have gone much further; and led away by the fact that fractures in the upper extremity do not prevent patients from getting up, have sought to extend this liberty to the lower extremity. Amesbury, if I am not mistaken, was the first to let patients walk with broken legs. In his apparatus, the leg and thigh were fastened by straps to a very light double inclined plane, and moreover confined by lateral splints. A sort of sling fixed to the end of the leg-piece served to suspend the weight of the limb by the patient's neck; and he was thus enabled to walk on crutches after about the third to the eleventh day, according to the state of the limb; in 1831, the author published several cases thus treated with very good results. In 1832, M. A. Bérard, with the albuminated apparatus, allowed patients with fracture of the leg to walk about; lastly, in 1836, M. Seutin extended the liberty of walking to all fractures of the lower extremity.

I must confess I have never been much attracted by this plan. In the first place, we must consider that it is of no therapeutic value; the surgeon seeks here only to please the patient, to dazzle him by a sort of *tour de force* not without some originality. When this involves no risk, we may certainly attempt it. Thus in fractures of the fibula, where the tibia serves as a splint and prevents displace-

ment, I see no objection to it; in simple fractures of the leg, after consolidation is somewhat advanced, we may resort to it, although the danger to the patient, from falls, should be seriously taken into account. But in recent fractures, in those especially in which the tendency to displacement cannot always be overcome by perfect rest, I regard this plan as an extremely imprudent one. Amesbury himself has made an exception in regard to oblique fractures; in these he keeps the patients in bed till the fibula is united, which occurs, he says, in fifteen days or three weeks; and again, in the simpler cases, he urges the patients never to move the limb by its muscles, but always passively, by means of the sling. A slight safeguard, and one to which few surgeons would be willing to trust! Moreover, in spite of his boasted successes, this plan in fractures of the leg has never made many proselytes either in England or in France; and I believe that even M. A. Bérard has abandoned it.

As regards fractures of the femur, since the best forms of apparatus, with rest in bed, so seldom effect a cure without shortening; since to the difficulties of the fracture itself are added the dangers of attempting to walk, without the hope of even the slightest benefit, such temerity happily needs no opposition; for I know of no surgeon in France who would be willing to make trial of it.

§ X.—*Of the Treatment of Complicated* Fractures.*

Although the indications established for the management of simple fractures have an equal value as regards others, yet the latter present themselves under such various conditions, that our precepts must be sometimes modified, and always extended, to suit them.

Thus reduction is effected by the same rules; but there may occur two circumstances which, increasing the difficulty and danger, involve new indications: first, when the fragments protrude through the integuments; secondly, when the fracture is comminuted.

In fractures of the thigh or leg, it is generally the upper fragment which thus protrudes, and only in exceptional cases the lower. The difficulty of reduction is in proportion to the narrowness of the wound and the length of bone projecting; if the wound is too small, we should boldly enlarge it in the direction and to the extent necessary for putting back the fragment; if this presents a long sharp point, hindering reduction in spite of the enlargement of the wound, it must be resected before making any fresh efforts.

Hippocrates recommended, in difficult cases, a resource which I am sorry to see dismissed from modern surgery; this was the *moch-*

* [*Compound*, according to the American and English nomenclature.]

licus, a sort of iron lever, like that used by stone-cutters, widened and flattened toward the end. Extension being made as usual, this lever was slipped in between the fragments, so that its lower face bore upon the lower fragment, while its upper face was applied on the end of the upper fragment, raising it and pushing it up to the level of the other.

But when we use such powerful means, and upon limbs which have suffered such violence, we should especially bear in mind the great rule, not to struggle against spasm and inflammation, but either to prevent them or wait till they subside. There may however occur here one of the greatest practical difficulties; shall we leave the end of the bone sticking out, to become necrosed, with all the chances of inflammation and suppuration entailed by such a displacement, and of the moral effect on the patient? Hippocrates has forcibly represented the surgeon's position: not to reduce it, says he, is to incur the reproach of ignorance; to reduce it is to increase the chances of death. However, he does not hesitate to prefer the patient's interest to that of the surgeon; he would not reduce. This is also the opinion of Boyer; if there is too much difficulty, says he, we had better wait for suppuration. Such cases are happily rare, and I have not for my own part had occasion to see them. It appears to me, however, that the advice of Hippocrates and of Boyer should not be followed unless the limb were attacked with an intense inflammation, involving the integuments; otherwise, we may adopt a middle course between total inaction and reduction, by bringing the projecting fragment from one side to the other, within the muscles, so as to restore at least the natural direction of the limb. I would say more: in the majority of fractures of the femur, for instance, when a fragment protrudes through the integuments, we cannot hope for complete reduction, so difficult even in simple fractures; and it would very often be highly imprudent to persist in attempting it.

[I have already alluded (see note on page 166) to two cases of this kind, in which the operation of resection of the projecting ends was performed, with satisfactory results.]

The fact of a fracture being comminuted does not imply much danger when the integuments are intact; and even when they are wounded, if the wound is small, and heals by the first intention, we need not be alarmed at the presence or number of the splinters. But when suppuration is inevitable, these splinters constitute an extremely grave complication; they act as foreign bodies within the tissues, and must be extracted as soon as possible. We have already had occasion to speak of the well-known fracture of the leg sustained by Paré; it was compound and comminuted; so the great surgeon took care to advise Richard Hubert, who dressed the injury, "*que si la playe n'estait suffisante, qu'il l'accreust avec vn rasoir pour remettre*

plus aisément les os en leur position naturelle; et qu'il recherchast diligemment la playe auec les doigts, plustost qu'auec autre instrument (car le sentiment du tact est plus certain que nul autre instrument) pour oster les fragments et pieces des os qui pourroient estre du tout separées: mesmes qu'il exprimast et feist sortir le sang qui estoit en grande abondance aux enuirons de la playe." *

A. Paré put in practice for himself the precept which he had first announced for fractures by gunshot, which are *par excellence* comminuted, and for which he recommended, in 1545, to begin by extracting all the splinters which are *separated.* This rule is retained to our own day, but not without some important modifications. I have already said (see *ante*, p. 115) how often gunshot fractures, even after consolidation, become the seat of small abscesses, each from the separation of a splinter; and the most expert surgeons, after extracting with the greatest care all the detached pieces, have observed similar consecutive eliminations. Often even those splinters which adhere are thrown off before the consolidation is complete; A. Paré had this to go through with. Percy, therefore, modifying Paré's rule, left only such splinters as he thought could be again united; "Those," he adds, "which did not seem capable of such reunion, should be separated from their connections, and treated as foreign bodies likely to do mischief."† But recently M. Baudens has gone farther, and would advise the extraction of *all the movable splinters caused by gunshot fractures of the body of a long bone, whether adherent or not.* The facts upon which M. Baudens relies are worth stating.

An Arab had had both bones of the forearm broken by a ball. The free splinters were all removed; but during eight months fresh discharges of them successively took place, and the patient at last succumbed from purulent infection. The bones were found partly united by a very voluminous eburnated callus, having a great many radiating cavities still containing movable splinters about half discharged.

A young soldier had received a ball at about the lower third of the ulna; the free splinters were removed, and the adherent ones left. Four months afterwards, numerous splinters, successively escaping, kept up an active general and local irritation. M. Baudens made free incisions, and drew out a dozen splinters of different sizes, so as

* ["That if the wound were too small, he should enlarge it with a razor, so as more easily to replace the bones in their natural position; and that he should carefully explore the wound with his fingers, rather than with any other instrument, (the sense of touch affording the greatest certainty,) in order to remove such fragments and bits of bone as might be completely detached; pressing out and evacuating also the blood which was abundantly effused about the wound."]

† Percy, *Manuel de chir. d'armée*, p. 193.

to leave no foreign bodies in the wound; two months afterwards, consolidation and cicatrisation were both complete.

Another had had the ulna broken an inch below the olecranon. The surgeon made an incision two and a half inches long, and took out three movable splinters, leaving two others because they adhered strongly to the soft parts, and especially because they entered into the articulation. At first everything went on well; but at different times there occurred swelling and heat around the fracture; finally, the suppuration still continuing, a probe was introduced, detecting some bits of necrosed bone, which were extracted after enlarging the wound. These were the splinters which the surgeon had endeavored to save, because the tendon of the triceps was firmly adhered to them; their removal was speedily followed by recovery.

M. Baudens cites also several cures of fractures of the tibia, obtained in this way. He makes, however, two exceptions to the rule; the first for fractures of the femur, which according to him imperatively demand amputation, a view which will be hereafter discussed; the second for fractures of the facial bones. Here, in fact, the vitality is so great, and the reparative process so energetic, that adherent splinters can and ought to be preserved, and extraction should be confined to such as are entirely detached. In the case of the lower jaw, however, the vitality is less, and the ordinary rule holds good.*

These facts, we think, demand the serious attention of surgeons; we see, moreover, that the practice of M. Baudens is not so very novel, since that of Percy closely resembles it. Whichever course we adopt, we must give our incisions the full extent necessary for extracting the pieces with the least possible dragging and pain, and such a direction as to facilitate at once the dressing, and the escape of pus; and we should also avoid as much as we can opening the great muscular sheaths, so as not to have protrusions of the muscles. The finger, according to Paré's precept, should be the first instrument carried to the bottom of the wound to detect, loosen, and seize the pieces; and if it does not itself do all, it should at least direct our other instruments. Lastly, when by means of incisions we have brought the fragments, without excessive difficulty, to the external opening, it is well to resect any sharp points which would irritate the tissues and prevent proper coaptation.

Reduction once made, we have only to maintain it, just as in simple fractures; but we must carefully attend to the dressing of the wound.

The wound may present itself in various conditions. It is sometimes small, with its edges uncontused, and seemingly ready to unite by the first intention; this union, making the fracture a simple one,

* *Gazette des Hôpitaux*, 1836, pp. 366, 379, 386, 487.

should be the point aimed at by the surgeon. To obtain it, it generally suffices to cover the wound with a little diachylon or lead-plaster; but one essential precaution is to protect this part from all pressure, and even to leave it exposed, under our continual inspection. J. Hunter occasionally substituted for the plaster a bit of charpie dipped in the blood; a practice imitated by Sir A. Cooper, and highly lauded by Amesbury. I have several times found this plan useful, but have succeeded quite as well with the plaster; and Hunter himself recommends one or the other indifferently.

The case is not so plain when the wound is large, irregular, cut in flaps, with edges more or less bruised. Hugues de Lucques first united these wounds by suture, embracing the skin and adipose tissue, but avoiding the muscles, and leaving the whole untouched for ten days afterwards. Theodoric, who has preserved to us this plan, says that he has tried others, but none so successfully; Guillaume de Salicet and Guy de Chauliac adopted it after him, and were imitated by Fabricius d'Acquapendente and Wiseman; only this last author established a distinction between ordinary compound fractures, without very great contusion of the skin, and gunshot fractures, in which the suture could not be used. In our times it is pretty generally abandoned, and in the classical treatises it is not even mentioned. Such neglect seems to me by no means justifiable, and in the following case I had reason to congratulate myself on having employed the suture.

A carpenter, fifty years of age, was using a jack to raise an enormous mass of wood; the jack slipping, the beam fell on the inner side of his right leg, tore the integuments into a flap for an extent of three and a half inches, stripping them from the tibia for one inch, and broke both bones at the lower part of the wound, about six inches from the ankle-joint. Notwithstanding the attrition of the skin, I attempted to obtain union by means of five points of the twisted suture, and one of the interrupted. The pins were withdrawn on the fourth day, and union seemed to have taken place, when some days afterwards a slight inflammation was set up around the wound, separating its edges, and giving exit to some pus. But the union at the bottom of the wound was firm, protecting the fracture from the air; and at the end of two months consolidation was complete.

Here the advantage was very great, and cheaply obtained. Suppose, indeed, that the suture had failed; things would only have been reduced to their original condition, without any more danger to the patient. I think then that in such a case the suture affords an invaluable resource, if used with judgment.

When lastly the wound is not of a nature to unite either by means of plaster or the suture, we must expect a tedious suppuration, attended also with danger; and the necessity of combining attention

to such a wound with the treatment of the fracture has given rise to a good many plans and forms of apparatus. We shall study these last in the same order as those for simple fractures.

We have already said that for certain fractures attended with wounds, Hippocrates had recourse to the many-tailed bandage, applying first the strip which should cover the wound; he insisted first of all on the wound being covered; but another school cotemporary with him conceived of enveloping in bandages and compresses the rest of the limb, leaving the wound exposed, so that it might be conveniently dressed without deranging everything. As to the splints, Galen recommended putting them on each side of the wound, so as to avoid pressing too much upon it.

This system of leaving an opening in the bandage was retained in Upper Asia in spite of the opposition of the greatest masters; Rhazes found it in full force, and tried in vain to overthrow it; and we see it finally adopted by Avicenna and Albucasis. Avicenna arranged his bandage so as to leave the wound free, and even made a corresponding opening in the splint; Albucasis appears to have been the first who thought of applying the bandage in the ordinary way, and afterwards cutting out with scissors a hole of the required size. Afterwards, J. L. Petit, going back to the many-tailed bandage, applied it in the opposite mode to that of Hippocrates, keeping the last strips to cover the wound, in order to be able to replace them, when soiled, without deranging the others or disturbing the limb. All the modifications attempted since are included under those we have mentioned, until the change I have introduced in apparatuses of this kind, which consists in applying the splints and their padding merely, without any bandage whatever.

All the apparatuses with splints are constructed with the idea that it is necessary to dress the wound frequently; only sometimes the dressing requires a complete removal, sometimes only a partial one, and at other times is accomplished without any disarrangement whatever. The albuminated apparatuses of the middle ages were at first made with an opening opposite the wound; Hugues de Lucques and Theodoric alone applied a complete bandage, which they renewed at first not before the tenth day, but afterwards every seven or eight days. Larrey, in our own day, went further; he applied his apparatus just as for simple fractures, and removed it only when union was complete. It was of no account, in this method, if the suppuration was abundant; the pus flowed out between the dressing and the limb, and was merely wiped away; if it soaked the bandage so as to lessen its solidity, new compresses were applied on the outside. Maggots even might be engendered beneath the apparatus; this was, according to Larrey, an advantage, since they ate away the dead parts, and hastened the cleansing of the wound; and he only renewed the dressing if they became too numerous, their number only being the

source of trouble. This plan, however, has not been generally thought prudent, and M. Seutin cuts his starch-bandage after the manner of Albucasis, while M. Velpeau applies his dextrine apparatus so as to leave the wound exposed, as did the ancients, and as did Avicenna.

When the plaster-dressing is used, an opening is likewise left opposite the wound; and thus, as we have seen, the Arabian bonesetter proceeded, the account of whose treatment is given us by Eaton.

In the same way, when cuirasses are used, they are furnished with an opening for the examination and dressing of the wound, and I need add no more to what has been already said.

Troughs, boxes, cushions, slings, boards, and all the forms of hyponarthecic apparatus, may be applied almost without modification to the treatment of compound fractures, since they leave exposed so large a portion of the limb. If the wound is at the posterior part, we may make openings in the box or trough, leave out one piece from the sling, replace the board by an open frame; I shall merely allude to the apparatus of Gray, consisting of three trough-like portions, supported by three uprights placed at suitable intervals; one portion was fitted to the knee, another sustained the leg, and the third was provided with a foot-board, to keep the foot in place.*

Lastly, apparatuses for making permanent extension are still more convenient for dressing the wound, since they keep the limb fixed without entirely concealing any part of its circumference; and it was for compound fractures that Hippocrates conceived the apparatus for distension, before spoken of.

In fine, these forms of apparatus present three varieties: the first comprises those in which the apparatus must be wholly or in part removed at each dressing of the wound, thus involving inevitably some motion in the limb; the second those in which the wound is dressed the first day and then left to itself; and the third those in which the dressing of the wound and the immobility of the limb are at one and the same time provided for.

Of these three plans, the first, comprehending all applications of rollers or bandages sustained by splints, from the apparatus of Hippocrates to that of Boyer, should be absolutely rejected; the necessary movements of the limb, besides retarding consolidation, directly inducing inflammation and suppuration. The second, in spite of some brilliant successes, is subject likewise to too much inconvenience and danger. The first annoyance, which is certainly one of the least, is the fetid exhalation sometimes taking place from the apparatus. I have seen at Val-de-Grâce a mere extravasation of blood between the compresses, which compelled us by its odor to change

* *The London Med. and Phys. Journal*, Sept., 1825. Richter has also given a representation of this apparatus.

the entire dressing of a fractured leg. Another very palpable inconvenience is the loss of solidity of the bandage, when the suppuration is copious enough to soak through the whole thickness of the compresses. When things reach this point, the pus flows between the skin and the dressings; one portion stagnates in the interspace due to the emaciation of the limb, while the rest flows continually toward the heel, giving out a horrible smell.

All this would however be still trifling. But unhappily we have too much reason to fear that the pus will burrow between the integuments and the muscles, and between the muscles and the bone, endangering the limb and even the life of the patient. I have elsewhere published the case of an old soldier, a stout, sanguine man, who fell from a ladder, and sustained a compound fracture of the tibia at its lower part. The immovable apparatus was employed; on the eighteenth day it had to be removed on account of the insupportable fetor. Four days later, pus flowed abundantly by the heel. On the twenty-ninth day, the increased discharge and the excessive fetor made a fresh removal necessary; the whole leg was pasty and flaccid; there was no trace of callus; a probe, introduced by the wound, passed up several inches between the two bones; the tibia was denuded at its external face; sinuses were formed in the limb above and below. Several surgeons regarded amputation as unavoidable. This however was postponed, and by great care, after three incisions had been made, and a long train of severe symptoms had been overcome, a satisfactory cure was effected by the end of six months.*

It avails little for the partisans of the plan to call this case an exception; no prudent surgeon would expose a patient to such unpleasant exceptions.

There remains the third plan; and this may be divided at once into two great methods, according as we either inclose the limb in a complete envelope, open only opposite the seat of the fracture, or leave the limb exposed.

The former mode of proceeding has been strongly criticised by Hippocrates himself. The wound, alone remaining free in the midst of compression, soon swells and assumes an unfavorable aspect; its edges become everted; serum is discharged instead of pus; the patient experiences febrile heat and throbbing; and Hippocrates concludes by saying: "*I would not have so much dwelt on this method, had I not fully known its dangers, and of what importance it was to warn practitioners from adopting it.*"

Some of these symptoms doubtless arise from the apparatus being put on before the inflammation has subsided; and it is certain that they do not so constantly supervene as Hippocrates would seem to

* *Lancette Française*, June 17, 1830.

teach. But the danger has struck several of the modern partisans of the plan, and not merely as regards swelling of the wound; for by hiding the parts around, we also cover up from view any abscesses or sinuses which may form in the vicinity. The following case, which I take from the *Clinique* of M. Velpeau, will show plainly enough what we have to fear.

A compound fracture of the leg was sustained by a man thirty-eight years of age; a dextrine bandage, open opposite the wound, was applied. On the sixteenth day, there was found by means of a probe a fistula extending about two inches downward from the wound. The apparatus was renewed, leaving both wound and fistula exposed. The twenty-first day, there was fever, and an abscess had formed between the wound and the fistula; this abscess was opened, and by this opening the end of the upper fragment was felt to be bare. Some days after, there were symptoms of purulent infection, and death ensued on the twenty-ninth day.

I am certainly far from pretending that any apparatus whatever would always afford security against similar accidents; but I would have the surgeon on his guard, and I would have such dressings used as would permit him to keep a careful watch over the whole surface of the limb, to recognise the symptoms and to combat them at once. Strange! physicians, having to deal with organs they cannot see, exhaust their art to explore them, to sound the depths of the visceral cavities; to read through the thickness of their walls, to translate as it were the malady to the exterior; while we surgeons, having before our eyes abscesses, diffused inflammation, sinuses, wounds, seek to hide all this with our bandages, and to deprive ourselves of what I would call our *ante-mortem autopsy*.

I therefore discard the immovable apparatus, and the plaster apparatus, which is more dangerous because it exerts more compression; or at least, I would not resort to it until long after all danger of inflammation, or of the formation of sinuses, had passed away. Even cuirasses are unsafe, because they also conceal too much. We are not however without available means.

If the wound is trifling, and the displacement little or nothing, we have at hand the entire hyponarthecic apparatus, cushions, troughs, boards, etc. For greater security, after having laid the limb on a board or a double inclined plane, I add at the sides junk-bags and splints, without bandages or compresses; œdema is best prevented by giving the limb a raised position. The wound, when it cannot be closed, is dressed with a simple bit of lint, covered only by a light compress. The simplicity of this treatment is evident; nor need we concern ourselves to settle the question how often the limb is to be re-dressed, as we must when other plans are adopted. In practice, having the wound and the parts around it, always in view, I leave

the lint in place as long as no change occurs; as soon as any new condition arises, inflammation, suppuration, or what not, I am ready to meet it. If the wound is at one side, I put a splint only on the opposite side, retaining it in place by two cravats, by a dextrine bandage, or better still, by two wide strips of lead-plaster. If the wound is beneath, and the limb cannot be so placed as to leave it at one side, one cushion should be arranged above it, and another below, so as to guard against any pressure upon it; or we may replace the board by an open frame, or by a special apparatus like Rae's box.

When the fragments are considerably overlapped, burying their sharp points in the tissues, we must resort to permanent extension. But in comminuted fractures, when we have had to remove a good many splinters, or to resect the end of one fragment, or when, from whatever cause, the fragments are obstinately separated from one another, lateral compression, which even under other circumstances is not always reliable, cannot be safely applied to the parts surrounding an irritable wound; and here is a real deficiency. In these difficult cases, recourse has been had to *ligature* or *suture of the bone.*

The first mention of the ligature dates back to the last century. Icart, surgeon of the Hôtel-Dieu at Castres, says he saw it used with success by Lapujade and Sicre, surgeons of Toulouse; and he himself defends it against the attacks of Pujol.* The plan consisted in embracing the fragments with a tightly-drawn wire of brass, silver or lead, to be left in place until the fragments no longer needed it to hold them together. I know of no one who has used the ligature since then except M. Baudens; he applied it in a compound fracture of the jaw.

The suture is much more modern; attempted at first, after resection, as we shall see further, it was applied in 1838 by M. Flaubert of Rouen, in a compound fracture of the humerus from crushing by a wagon-wheel. The extraction of a very large splinter had left the two fragments, slender and very sharp, approaching one another only by their points. The suture was applied just as after resection; unhappily, about the eighth or tenth day, the lower fragment became necrosed; and the thread, which had cut through the upper fragment after three or four weeks, came away with the necrosed portion of the lower at the end of six weeks. Union had however begun, and although delayed by all these untoward circumstances, was completed firmly in a few months.†

These are undoubtedly extreme resources, and should only be adopted in extreme cases. Sometimes necessity gives great value to means which we may commonly despise. M. Warnier has related

* Pujol, *Mémoire sur une amputation*, etc.; Icart, *Lettre en réponse au Mém. de M. Pujol;* Pujol, *Eclaircissements en réponse*, etc.; *Journal de Médecine*, 1775, tome xliii, p. 160, xliv, p. 164, and xlv, p. 167.

† Laloy, *De la suture des os*, etc., Thèse inaug., Paris, 1839.

the case of a Mahometan priest who was shot in the upper part of the thigh. Three Arabian apparatuses (*djebira*) were successively applied without any benefit; the priest buried his limb in sand, which absorbed the pus; and at the end of a year of perseverance, the femur had united with a shortening of eleven centimètres, [nearly four inches,] so as however to allow of his mounting a horse, and even travelling some distance on foot.*

I shall conclude this section with an important practical remark. The danger lasts until the wound is closed, or at least lined by a solid pyogenic membrane, and shut off from communication with the fracture. After this the treatment becomes much simplified, since we have only to watch the consolidation; and any apparatus, immovable or otherwise, may be conveniently applied.

§ XI.—*Of the Treatment of Symptoms.*

After the reduction, and the application of the dressings, there remains to be performed by no means the least important duty of the surgeon; he must use all care to ward off unfavorable symptoms, and to remedy them when they come on.

A fracture which is simple from the first, or which becomes so during the treatment, demands only that the patient should have a regimen sufficiently generous to afford materials for consolidation. This regimen should be first of all substantial and abundant. Fabricius Hildanus has remarked that the use of gelatinous food retards consolidation; and I have before mentioned several cases in which insufficient diet had plainly exerted such an influence. Hence in all cases of fracture, I hasten to bring the patients back to their usual food, from the first day if there is no inflammation, or at any rate as soon as the inflammation has subsided. Boyer advises one or two bleedings in fractures of the lower extremity, even when simple, keeping the patient on broth for the first few days, then allowing soup, and later gradually bringing him to more solid food; lastly, he prescribes some soothing and refreshing drink. In spite of so high an authority, in fact on account of the weight it carries with it, we must say plainly that this course is not founded in reason. We may bleed, if it be indicated, and prescribe diet and tisanes if they are indicated; but if the pulse is calm and the appetite good, dieting and bleeding are, to say the least, useless.

Another much abused means is the application of topical remedies to the broken limb. Hippocrates smeared it with cerate; Hugues de Lucques rubbed it with a bacon-rind, and afterwards covered it with honey. Duverney used compresses soaked in camphorated

* Warnier, *Du trait. des plaies d'armes à feu chez les Arabes Bédouins de l'Algérie*, Thèse inaug., Montpellier, 1839.

brandy or with lead-water; Larrey, fomentations with camphorated vinegar, etc. All this is mere empiricism, without any object, or any plausible reason. There is no objection except its uselessness to the application of a moist compress; but fatty or oily inunctions irritate the skin, cause eruptions and very uncomfortable itching, and sometimes even bring on erysipelas. Fomentations, continued during several days, induce a sodden state of the limb, and hence it is better not to employ them.

But there may occur in the course of the treatment various local and general symptoms, several of which might well be called complications, if custom had not limited this word as before mentioned.

The local accidents may be *primitive* or *consecutive*. Among the former we place contusions, excoriations, phlyctenæ, extravasations of blood, primitive false aneurism, muscular spasm and inflammation.

(1.) *Contusion* may be slight or serious, limited or extensive; it is sometimes accompanied by ecchymosis spreading widely among the cellular tissue. To whatever degree it occurs, even if it is severe enough to make us dread gangrene of the integuments, we can do nothing to dispel it. The majority of surgeons resort in such cases to topical remedies called resolvents, which we shall soon have again to mention; I myself long followed this practice. Dissatisfied with its results, I sought to find something more reliable; and in extensive ecchymoses, for instance, I frequently tried fomenting one portion with camphorated brandy, with lead-water, etc., leaving the rest exposed to the air merely; resolution occurred as readily in the one as in the other. The only really important indication is to ward off subsequent inflammation; for this we should resort to bleeding and low diet; and the best of all topical applications are emollient cataplasms. But if there is no sign of inflammation, it is best to leave the work to time and nature, taking care only to guard the contused part from undue pressure.

(2.) *Excoriations*, or even open wounds, not communicating with the seat of fracture, should be treated in the simplest manner, and as if no fracture existed; all pressure on them should be avoided.

(3.) *Phlyctenæ* resulting from the violence of the contusion are unimportant, and should be carefully distinguished from such as precede or accompany gangrene. Boyer recommends opening them, leaving the epidermis undetached, and putting on a rag smeared with cerate. This plan is not troublesome, and is not without its advantages when we want to apply a circular bandage to the limb; but if we leave the part exposed to the air, we may content ourselves with emptying only the largest vesicles by puncture, leaving the rest to absorption.

(4.) *Bloody effusions* occur under two different forms. Sometimes we have an infiltration of the limb, greatly augmenting its volume, but nowhere presenting any fluctuation; if we can keep

down inflammation, resolution almost always occurs. Boyer cites a remarkable case of this. A bleacher broke his leg by falling from a wagon. Three or four days afterwards, the limb swelled enormously, and the skin became purple and mottled. It was thought that the anterior tibial artery had been injured; nevertheless, the infiltration making no progress, nothing was done but to bleed, and to apply emollient cataplasms locally. Under this treatment the tension rapidly diminished, and the engorgement passed away, leaving however a large ecchymosis, which gradually disappeared.

Another and more serious form, is when there is a large effusion beneath the skin, fluctuating, and raising the integuments like those over an abscess. In such cases Bromfield did not hesitate to make free openings, and Larrey adopted the same practice. Undoubtedly a slight complication is thus disposed of, but only at the risk of a greater,—at the least a suppurating wound, and in the majority of cases a direct communication between the fracture and the atmosphere. Hence most surgeons prefer leaving such collections to nature. They generally end in absorption; but it is very important that no pressure whatever should be exerted on the skin, tense as it is, lest a slough should be induced; and the safest plan according to my experience is to leave the part open to the air, without any sort of application, unless inflammation should come on and change the aspect of things. If however absorption should not occur, we can at any convenient time make an opening, perhaps after the fracture is united. I have but once seen a collection of this kind resist absorption, without the occurrence of suppuration; the case may be briefly given as follows.

A coachman, thirty-eight years old, had his leg broken at the upper part by a carriage-wheel passing over it; a vast collection of blood distended the integuments, which seemed very much thinned; fluctuation was very perceptible, and the least movement gave rise to a good deal of crepitation. When he was admitted into the hospital, the resident physician covered the limb with a compress soaked in lead-water, and placed it on a cushion, supporting it by two lateral splints. Next day I had him bled to four bowlfuls, [sixteen ounces; each *palette* or bowl containing four.] On the third day there was a good deal of swelling and redness of the integuments; he was bled to three bowlfuls; emollient cataplasms were applied, and continued until the twenty-second day. The effused blood was in great part absorbed; there remained, however, a spot of fluctuation which threatened to open, for the skin became very thin and assumed a violaceous hue. On the forty-first day I concluded to evacuate it by puncture; there flowed out from forty to fifty grammes of a reddish-brown, thick liquid, like chocolate, without any coagula, but with some few small masses of fat. The microscope discovered no pus-globules in it. Suppuration was now speedily set up in the

cavity, and I had to make free incisions. Still, the consolidation was quite advanced, and the abscess acted like a simple one; it closed in less than three weeks, and on the eighty-third day after the fracture the patient walked about on crutches.

The premature opening of this collection, introducing the external air to the seat of a comminuted fracture, would assuredly have greatly delayed the cure, to say nothing of the danger to which it would have exposed the patient.

(5.) *Primitive false aneurism* is nothing more than an effusion of blood, caused and kept up by a wound of an artery. The difference then between this and ordinary extravasation from veins or capillaries is, that this effusion tends to increase rather than to diminish, pulsations are perceptible in it, and the necessity of checking it is urgent.

A case of this kind is related by J. L. Petit. In a fracture of the leg, the anterior tibial artery had been wounded; the limb was ecchymosed, became cold and livid, and was believed to be gangrenous; Petit made an incision three fingers'-breadths long, laid bare the artery, and arrested the bleeding; the fracture united in the usual time.

In spite of this remarkable success, Pelletan amputated the thigh in three cases of fracture of the leg with effusion of arterial blood, and lost two of his patients.* Boyer, without any personal experience on the point, thought that we should cut down upon the artery, and tie it above and below the point of injury. Lastly, in 1809, Dupuytren employed successfully the ligature by Anel's method,† and advised it for all cases of this kind.

In a case of fracture of the leg at the inferior third, on the second day there were pulsatile movements in the calf, perceptible both by the sight and by the touch, isochronous with the pulse elsewhere, and immediately arrested by pressure on the femoral artery. Dupuytren ligated this vessel at the middle of the thigh; the tumor gradually disappeared, and the patient recovered simultaneously from the effusion, the operation, and the fracture.

In 1815, Delpech had a similar case, with a similar result; and so also had subsequently Mr. B. Cooper, in a patient with an injury of the popliteal artery by fracture of the femur.

Such is therefore the plan to be pursued in preference to that attempted by J. L. Petit or that advised by Boyer. But although effusions of this kind ordinarily occur almost at the same time as the fracture, there are cases in which they do not show themselves until much later. In one observed by Pelletan, the extravasation did not

* Dupuytren, *Des anevrismes qui compliquent les fractures; Léçons Orales*, second edition, tome ii, p. 507.

† [The same as that of Hunter, viz., at some distance above the affected part.]

appear till after the thirtieth day, the only precursory phenomena having been pains in the calf, coming on at about the fifteenth; after the amputation, dissection of the leg showed a rupture of the peroneal artery. When the aneurism has been so long in developing itself, should we not dread its being maintained from the distal portion of the vessel, and prefer ligating above and below the seat of injury? The history of these arterial effusions shows indeed that Anel's method is not certain in such cases; and it may be added that after thirty days the fracture would be so far advanced toward union that we need have very little fear of our incision doing harm by laying it open to the air.

There remain, lastly, wounds of arteries complicating fractures which are already compound, and hence bleeding externally. Is the ligature then equally successful? In spite of J. L. Petit's case, Dupuytren hesitates, and evidently inclines to the opposite opinion. However, except in case of such injury as would render the preservation of the limb impossible, I confess that I should try the ligature before resorting to amputation.

(6.) *Muscular spasm* occurs in very variable degrees. "In fractures of the lower extremity," says Boyer, "and particularly in those of the leg, it sometimes happens, during the first two or three nights after reduction, that the injured limb is affected with convulsive twitchings, wakening the patient with a start, and deranging the fragments so that they must be reduced anew." This remark is very true; I would add that the same phenomenon takes place in some patients in whom there is no displacement, and may even in doubtful cases strengthen our suspicion that fracture exists. These spasms, unless violent, are of trifling importance; we endeavor to soothe them by slightly flexing the leg, with special care that no portion of the limb is wrongly placed; and at most they call for an anodyne, or for an emollient poultice. Violent spasms, interfering with reduction, even before the inflammatory period, should be remedied by bleeding, low diet, and antiphlogistics; and I have found it useful to add to these means full doses of opium.

It is so also with cases in which inflammation and fever are present, and particularly when the fragments have torn the integuments and protrude externally. Dupuytren, in speaking of fractures of the fibula with luxation of the foot and exposure of the tibio-tarsal articulation, gives a frightful picture of "the consecutive and permanent pains, resulting from the displacement of the bones, the piercing, tearing and distension of the soft parts; the inflammation, swelling and compression increase; they are accompanied by insomnia, fever, restlessness, spasms, involuntary and constant contractions, at each of which the fragments are displaced afresh, and the soft parts further injured, and which finally pass into convulsions and tetanus unless their cause is removed. Soothing remedies," he adds,

"may moderate these symptoms; narcotics, given in full doses, may prevent the pain from being felt; but as they leave untouched the cause and some of its effects, while leading us to trust to an amelioration which is only apparent, they inspire a false and fatal security. Thus it is that we have seen gangrene declare itself without any warning pain, in patients whose sensibility was deadened by narcotics given in too heavy doses."

I agree entirely with Dupuytren concerning the uselessness and danger of narcotics under these circumstances, and, indeed, generally when fever is developed. But when, immediately after, he says that the best means of allaying the disturbance is to reduce the fracture, when he says that by so doing we cause the disturbance to vanish at once, as by a charm, I cannot too strongly oppose an assertion so false and a precept so full of practical danger. He gives only one case in support of his ideas; but let us examine into this one.

A young woman, jumping from a carriage, luxated her foot inward; the fractured tibia and fibula protruded through a large wound on the outside of the ankle-joint. The pain was terrible; reduction was performed. The pain continued through that day and the next, and the patient was tormented with constant spasms; in spite of bleeding and of soothing remedies, they kept increasing, eliciting every moment shrieks from the sufferer. On the ninth day tetanus set in.

Now, I ask, could we find a fact which would more grievously contradict the doctrine? And yet this is by no means the only such case; I have already quoted two others given by Sir A. Cooper, in which reduction was quite as unsuccessful, (see page 166;) and modern experience has only confirmed the opinions formerly held on this point.

I repeat, then, with Hippocrates, that spasm is so far from being allayed by reduction as to constitute a capital objection to any attempt at it. What, then, is the course to be pursued? Place the fragments in that position in which they will do least injury to the soft parts; resect, if necessary, the protruding portions; relax the muscles by semiflexion; and employ bleeding, and the most energetic depletory remedies.

(7.) *Inflammation* is rarely absent at the outset in fractures with displacement. But sometimes it is slight, unattended by redness of the skin, and recognised only by the pain, swelling, and muscular contraction; mere rest is sufficient to allay it; or at most we have to employ emollient poultices. If, without involving the skin, it induces fever, bleeding may become necessary. Lastly, when of a still higher grade, affecting the whole thickness of the limb, reddening the skin, in a word assuming a phlegmonous aspect, we must not hesitate to bleed copiously and repeatedly; but in all cases the sur-

geon should remember that the most powerful antiphlogistic is absolute rest, and that so far from making any traction, or moving the limb at all, he should most carefully avoid everything which can possibly disturb it.

Inflammation of much greater severity attends compound fractures; here, in fact, small as the wound may be, suppuration is inevitable, and the torn soft parts are in some sort given up to purulent deposit. In these cases much value has been ascribed to irrigations, constant or occasional, with cold water; at one time they were in very general favor. I have had occasion to examine the question specially, and a close study of the facts has brought this mode of treatment down to its true place. Among thirty compound fractures of the leg treated by continuous irrigation, I have found three deaths: one was dismissed with non-union and a fistulous wound; three others, after having had chills, fever, abscesses, and sloughing, finally reached a cure at from the 172d to the 228th day; another, after having numerous sloughs, was cured, the time not given; lastly, five cures were obtained as in ordinary cases. A fracture of the arm, thus treated, was attended with chills, fever, and purulent deposits, but healed by the seventy-third day. M. Breschet, to whom nearly all these cases occurred, was so impressed by them that he has given up the employment of any but warm irrigations.

Occasional irrigation, by means of compresses moistened from time to time, was used with entire success in two cases of fracture of the leg, by M. Josse and M. Dubourg; and on the whole this plan seems to me to have as many advantages and fewer inconveniences than that of continued irrigation. The latter, however, would appear to be more particularly adapted to gunshot fractures of the foot or hand; but if we think fit to employ it, we should recollect that the chances of success are less in winter than in summer, and that in inflammations extending beyond a certain depth, it will only mask the symptoms, and should be absolutely rejected.*

This completes the list of primitive or primary epiphenomena, although it has been necessary, in order to avoid too many subdivisions, to place under the same head such as appear at the time the fracture is received, and such as only appear some hours or days after. The consecutive symptoms have dates even more various; some of them may come on very early, as soon even as some which I have called primitive, such as suppuration, and gangrene; others always appear later, such as necrosis, fistulæ, erysipelas, and local scurvy.

(1.) *Suppuration* is always of late occurrence in simple fractures, while it is really a primary symptom of such as are compound. In the latter the pus naturally flows out by the wound, and provided the

* Malgaigne, *De l'irrigation dans les maladies chirurgicales*, Paris, 1842.

fragments are kept perfectly in position, all the surgeon need do is to maintain a free exit for the matter, wiping it off as little as possible in renewing the dressings, unless it be in excessive quantity; he may moderate its amount by emollient applications or by a few leeches. The dressings should be very simple; in many cases a bit of lint and a light compress will suffice.

When an abscess forms at the seat of a simple fracture, we must wait till it is mature, then open it freely, and in such a way as to favor the discharge. If sinuses form along the limb, we almost always have to make counter-openings; and the indication being once plain, we should make our incisions both promptly and freely.

(2.) *Gangrene* may be of large or small extent. Sometimes it is the direct result of contusion; sometimes of excessive inflammation in the limb; but much more frequently it is from the pressure of the apparatus causing sloughs at points which are not well protected, such as the heel; lastly, occasionally the fragments cause it by pressure from within outward. On our knowledge of these causes is based our prophylactic treatment. As to subsequent treatment, I have only one remark to make; if we would remove the sloughs as soon as possible, cleanse the wound, and hasten cicatrization, we should resort to emollient cataplasms. If, on the contrary, we have any reason for delaying their separation, I have found by direct experiment that resin-plaster answers this purpose perfectly.

(3.) *Necrosis* attacks the ends of fragments which have been denuded of their periosteum, exposed to the air, or bathed in pus. *Fig.* 7 affords a good example of this; the end of the lower fragment of the tibia, and the intermediate splinter, are necrosed, and we see in the adjoining portions of the bones the beginning of the work of elimination. To wait, trusting to nature, is the most prudent plan; the callus will form after the separation is accomplished. S. Cooper quotes a case from Schmucker, showing that even a tardy separation will not hinder consolidation. In an oblique fracture of the leg, a fragment of the tibia became necrosed, and at the end of eight months there was still a sinus on each side of the leg. Schmucker opened the sinus, and extracted the necrosed portion; when the fracture, which till then had remained movable, became firmly united in the space of two months. Norris likewise extracted a necrosed portion of the humerus four months after the occurrence of the fracture, and consolidation subsequently took place in one month.

(4.) *Fistulæ.*—As long as a particle of necrosed bone is still to be eliminated, it is very unusual for the wound to close; but it may gradually grow smaller, till it presents merely a fistulous ulcer. Some surgeons then think it right to stretch the opening with tents, or even to destroy its edges with caustic potash. J. Hunter showed this to be unnecessary, and that it mattered little if the opening became contracted or even closed, so long as the sequestrum remained

firm; excepting always in cases where the wound communicated with contiguous articulations, as in the foot and hand, or where the pus, thus confined, might burrow perhaps from one joint to the other. I think it may be stated, as a general rule, that unless the contraction of the wound induces some bad symptom, it should be let alone; but on the first suspicion of œdema, of inflammation, of alteration or stagnation of the pus, the orifice should be enlarged either with caustic, or with the bistoury. When, lastly, the splinter is separated, it need hardly be said that a sufficient opening should be made, and the piece extracted as soon as possible.

Sometimes fistulæ are kept up by a foreign body from without, as a ball or a bit of clothing; frequently by splinters not taken out in the beginning, or which, left adhering, have become detached. The splinter may be inclosed between the fragments, as in a case given by Faivre. A young man had for seven months suffered from a fracture of the tibia caused by the kick of a horse; the bone showed no tendency to unite, and amputation even had been spoken of. In raising the lower part of the limb, Faivre heard a dry sound at the seat of the fracture; having exposed the bone, he found interlocked between the fragments a splinter, an inch and a half in diameter, and comprising the whole thickness of the tibia. This was extracted; the ends of the bone, seeming to be altered, were cauterized, and six months afterwards the cure was complete.*

In a case of un-united fracture of the humerus, of two months' standing, Dr. Isaac Hulse, of New York, took advantage of a fistula remaining open to re-establish the work of consolidation. He threw in daily injections of a stimulating liquid, at first wine and water, then salt and water, and finally a solution of sulphate of copper. Union actually occurred in the space of two months, although the fistula remained; this was explained when there escaped first a little splinter, and subsequently, six months after consolidation, another large bit of bone an inch and a half long and an inch wide. The account goes no further.†

When a fistula, ensuing on a compound fracture, stubbornly refuses to cicatrize, there is always reason to suspect that a splinter will sooner or later escape. If this issue is too long postponed, we may enlarge the wound down to the bottom, with a bistoury; and even if we do not detect the foreign body, this little operation will be the best means of causing the fistula to heal up.

(5.) *Erysipelas* is one of the most common incidents in compound fractures, and its cause is not always easily detected. Sometimes the prolonged confinement to bed results in digestive derangement, and the erysipelas then arises from hepatic disorder. At other times

* *Journal de Médecine*, 1786, tome lxviii, page 210.
† *American Journal of the Med. Sciences*, Feb , 1834, p. 374.

we may suspect the stagnation of pus in some nook or recess of the wound; often the separation of a splinter of bone. [In the United States the general opinion is that erysipelas is a consequence of some hitherto undefined atmospheric state, and that any source of irritation may be an exciting cause. It is undoubtedly sometimes contagious, or at least so strongly epidemic as to amount to about the same thing; and we seek to attribute it not to the local injury, which may be the merest scratch, but to the more formidable predisposing cause; be this latter a peculiar condition of the atmosphere, or of the constitution, a contagion, or what not.] Erysipelas of broken limbs may be fixed or wandering, superficial or phlegmonous, often spreading over the whole member; it almost invariably leaves one or more abscesses. I have elsewhere mentioned its unfavorable influence on the formation of the callus; we see then the importance of studying its causes, to prevent its occurrence or its return. For the rest, aside from any special indications referable to the causes, the same treatment is called for as in ordinary erysipelas.

(6.) Lastly, at a more or less advanced period of the treatment, the limb may be attacked with *local scurvy*. The causes assigned for the development of this affection sufficiently indicate the course to be pursued to prevent it; when the first symptoms have already appeared, we must set ourselves more carefully than ever to guard the limb against dampness, to keep it exposed to the air and light, and to give a nutritious diet, with tonics and stimulants; applying locally embrocations with tinctures, and with aromatic and balsamic substances. M. J. Cloquet has employed these means with success; it has however seemed to me that their action would be much promoted by first dissipating the œdema. To this end, at first with the hands, I press and knead the limb so as to make the serum flow back toward the trunk, where it is much more easily absorbed; I afterwards continue the process by means of compresses and rollers; and sometimes I have succeeded in twenty-four or forty-eight hours in drying the whole limb, so to speak. The integuments having thus been somewhat refreshed, are more open to the action of the air, of the sun, and of stimulating embrocations; but it is well to bear in mind that the effecting of a cure demands often much time and attention.

The constitutional symptoms of fractures are such as attend other traumatic lesions. We shall say a few words only of fever, tetanus, nervous delirium, and lastly of sloughing over the sacrum.

(1.) *Primary fever* is usually allayed by diet and cooling drinks, and only calls for bleeding when some other affection is joined with it, such as spasms or violent local inflammation. If there should subsequently occur general excitement, gastric irritation, etc., they must be treated without reference to the fracture.

(2.) When *tetanus* occurs, is there any special indication to be

found in the fact of the fracture? Larrey tried amputation, and appears to have been somewhat successful, especially in chronic cases. It would seem indeed that this means attacked the evil at its root, and carried out the aphorism, "*Sublatâ causâ, tollitur effectus.*" But experience has sadly disappointed these hopes, and the failures have been so numerous that the successes obtained can hardly be attributed to more than chance.

(3.) Dupuytren has pointed out another complication, which he calls *nervous delirium*, because it occurs without fever, and yields admirably to opiates. He administered by enema, in a very small quantity of the vehicle, eight or ten drops of Sydenham's laudanum, [vinum opii,] repeating it if necessary three or four times at intervals of five or six hours. I have found opium given by the mouth to afford just as good results.

[This form of delirium may be distinguished from *delirium tremens*, in that it is not preceded by sleeplessness, the patient often waking up delirious, from a very sound sleep; it is more amenable to small doses of opium; there is far less gastric irritability; and the form of the hallucinations is not so much that of ocular spectra as of general excitement.]

(4.) Finally, it remains for me to speak of an accident which is thought to be very common in old persons with fracture of the lower extremities, and especially of the cervix femoris; I allude to *sloughing over the sacrum*. I for a long time entertained the usual idea on this point; but having been placed over the surgical wards at Bicêtre, I was soon convinced that the statements in regard to it were exaggerated. Old people endure lying in bed as well as other adults; whether they have fractures of the leg or of the cervix femoris makes no difference at all. I have treated the latter fracture in patients of seventy, seventy-five, eighty years, and more, without seeing any appearance of either excoriation or sloughing. I have also visited the paralytic wards, and seen old people who for years had lain upon beds without mattresses, and yet were without any sloughing whatever.

Whence then the common misconception on this point? We have seen patients confined to bed by fractures, incidentally attacked with some general or visceral affection, as scurvy, pneumonia, diarrhœa, etc. As soon as fever was thus set up, sloughing rapidly ensued, the more rapidly as the patients were thinner; and these exceptions were assumed to form the rule. I shall quote here but one single instance: an old man of eighty-seven years came into my wards June 2, 1841, with fracture of the cervix femoris. He lay at first for two months doing well; after this scorbutic spots appeared on different parts of his body, but he went to the ninetieth day without any sloughing. On that day he had fever; next day the skin over the sacrum was broken, and four days after, when he died, there was

a slough as large as a man's hand, at that spot. But is this peculiar to old people? I have often had proof to the contrary, and there was at that very time among the paralytics at Bicêtre a young man of thirty who had had his spine fractured by a land-slide; in the course of his treatment, he was attacked by a high fever, and had sloughs over the sacrum; afterwards, the fever having subsided, the sacrum was again covered over by good solid cicatrices, notwithstanding the obstinate persistence of the paralysis.

I hold then that neither the age of the patient nor the nature of the injury is sufficient to account for the formation of sloughs over the sacrum, and that these are always the result of some general affection. This would serve as a guide to our prognosis in some cases, and enable us to ward off the accident. Thus, if the general condition is good, even the oldest subjects endure extremely well confinement to an ordinary bed. If we have a compound fracture, with abundant suppuration, to deal with, especially in the lower extremity; or in the simplest fractures, if high fever comes on, we should hasten to relieve the sacrum from all pressure, by using a perforated cushion or mattress, or a mechanical bed. These precautions become still more indispensable after the sloughs have formed, to prevent their increasing in extent and depth; in severe cases we should even use Arnott's water-bed. Here particularly we wish to postpone as long as possible the separation of the slough, lest the pain and suppuration should speedily exhaust the patient; and for this purpose, experience has long since shown that it is best to cover the spot with a piece of lead-plaster.

§ XII.—*Of Convalescence from Fractures.*

When the time usually required for consolidation has elapsed, we remove the apparatus, and ascertain as far as possible that there is no mobility of the fragments; and we then allow the limb gradually to assume its ordinary functions. But this last point requires some precautions of no small importance.

When we have to deal with a simple fracture, without displacement, in the upper extremity, the period of treatment not having exceeded one month, and the articulations having been kept semi-flexed, the patient can generally use the limb immediately; at most it is necessary that he should for a day or two carry it in a sling, to prevent fatigue. In the lower extremity, after a simple fracture of the tibia or fibula, it is nearly the same; although here we must recollect that the limb has to support the weight of the body, and must give it for several days the assistance of two crutches. Convalescence is always speedy.

When the fracture has involved either the femur or both bones of the leg, it is better before the patient attempts to walk even with

crutches, to make him keep his bed some time, with the limb entirely unconfined, in order to exercise it without resting any weight upon it. These motions will give suppleness and strength to the limb without endangering the newly formed callus, and the plan can at least do no harm. However, the first time the patient quits his bed, we must expect at least one of the following phenomena to occur: redness of the limb, œdematous swelling, and a peculiar feeling of insecurity.

The redness is from the prolonged rest in the horizontal posture; the capillary and venous circulation seems to have lost its force; those vessels become turgid, and hence a redness more or less intense, sometimes purplish, sometimes bluish. Frictions with the hand, frequent use, the horizontal position when the redness becomes excessive, and lastly, if necessary, a roller applied so as moderately to compress the foot and leg, will generally overcome this symptom in a few days.

The œdema seems to proceed from the same cause, although it sometimes comes on without any redness. The treatment is the same; but the compressory bandage is indispensable for a few days. We may also use frictions with camphorated brandy, with aromatic wine, etc. According to my experience, dry frictions are quite as efficacious; but I am also convinced that they seem to the patient to be too simple, and are often neglected; I therefore take care to prescribe some medicinal liquid, with the sole object of making sure of the frictions.

The extreme timidity of patients about the use of their limbs, is a phenomenon which has received too little attention from surgeons. It sometimes depends on purely material causes, such as the weak and atrophied state of the muscles, the stiffening of the joints so that every motion to any extent induces pain, and lastly real pain, with a feeling of weakness, at the seat of fracture; I shall recur directly to each of these points. But apart from all these causes, there often remains in the patient's mind a mistrust purely moral, an instinctive fear that the limb has not sufficient strength to sustain him. This fear lessens and passes off in time, it is true; but sometimes convalescence is singularly retarded by it. Here the surgeon must interfere, must inspire security, must if needs be force it; for reasoning alone hardly ever avails against instinct. I have often seen, in my wards, patients furnished with crutches hold the foot up from the ground for eight or fifteen days. I tell them to rest upon it;—Monsieur, it is impossible. I take away one crutch, they grasp the foot of the bed, wavering, fearing to fall. Walk!—It is impossible. I bring them into the middle of the room; I tell them there is no danger; I push and urge them;—they walk as if stupefied. I take the other crutch from the armpit, make them grasp it like a cane;—they again resist, saying it is impossible. How-

ever, they walk; then I take away the stick and reach out one finger for their support;—they walk again. I withdraw the finger, and they still walk. I tell them to run, and they run. To remove all pretext for any new fears, I make them jump, first on the sound and then on the fractured limb; in the space of a few minutes, these men who could not walk with two crutches, thus run and jump without any crutches at all; their courage is entirely restored. It is well however, after this trial, to leave them the use of one crutch to save the limb from being too much fatigued; but we may be sure they will not employ it longer than is necessary, and will soon throw it aside of themselves. We must also, before making this trial, be well assured that the want of confidence is purely instinctive, and not founded on one of the three material causes which remain to be considered.

Atrophy of the limb may proceed from long-continued suppuration, from excessive pressure of the apparatus, or even from too prolonged inaction, especially when the air is excluded, as in an immovable apparatus. Frictions, douches, but always, and above all, exercise, are the best remedies for this; the exercise must, however, be adapted to the weakness of the limb; it should not be too violent, for fear of falls, nor too long-continued, for fear of fatigue. Atrophy is singularly favorable to œdema; hence it is necessary before the patient rises to envelope the leg in a moderately tight roller, which may be removed when he lies down again. The pressure is diminished from day to day, according to circumstances; and we carry the bandage also to a less and less distance up the leg. We also allow the patient the sun, fresh air and a nutritious diet.

Stiffening of the joints is one of the most annoying, and at the same time one of the most common, sequences of the usual treatment of fractures. I have pointed out the chief causes of it: inflammation, the extended position, pressure from apparatuses improperly made to surround the limb. The stiffening is so much the more marked as the contusion has been more severe, the fracture nearer the joint, the immobility more prolonged. Boyer has observed that it is much more considerable in the lower than in the upper articulation of the bone. It may attack also the most distant joints, if these have been kept confined.

It is very important to prevent this from occurring. We therefore leave the joints free from all pressure, keeping them in a medium position, and using occasionally passive motion. These motions should be so made as not to involve the fracture; hence it is necessary either that this should be firmly secured by the apparatus, or that consolidation should be somewhat advanced; and the surgeon should intrust it to no one but himself.

If, notwithstanding these precautions, stiffening will sometimes occur, we may judge of what takes place when they are neglected.

The fracture is cured, but the patient remains as powerless, or more so, than he was before. To carry the hand to the head, to put the foot on the ground, involves stretching of the ligaments, and pains like those of the rack; it is fortunate if real anchylosis does not ensue.

Two opinions have prevailed among surgeons concerning the treatment of false anchylosis. Some think that time alone will effect the cure, and leave their patients to this too often delusive hope; others, a little less confident, still know of nothing better than to employ frictions, emollients, baths and douches; baths of blood, of sulphurous or other waters, etc. Now nothing can be more empirical and dangerous than are these two plans of treatment. The only efficient remedy for stiffening of a joint is exercise; baths and douches can only soothe pain and favor these motions. If, then, we leave a patient to himself with a slight stiffening, which does not hinder spontaneous motion, time, added to the natural exercise of the limb, may suffice to overcome it; if it is more marked, neither time nor the unaided efforts of the patient will completely attain this end. If, lastly, it is still more serious, the patient being unable to execute any motion by himself, to send him to thermal springs is merely to condemn him to an incurability, the more certain since he is made to waste in frivolous attempts the time so invaluable for really effecting a cure. I have before cited several such cases, (see page 100;) the one I am about to relate will serve to show all the danger of delay. A planter in Havana had sustained a fracture of the cervix humeri; during the entire treatment his hand had been kept extended, and applied to his chest; when the apparatus was removed, his fingers were stiff, and entirely inflexible. He was given to believe that time would restore him the use of them; but several months having gone by without any improvement, he was sent to Barèges, [a village in the Upper Pyrenees, where there are sulphur springs.] He came thence to France, and consulted me at Paris. Seven or eight months had elapsed since the accident; I considered that there was no time to be lost, and urged him strongly to remain in Paris. But he had reasons for returning to the Pyrenees; there he lost three or four months, and came back in apparently the same state, but in reality with the stiffness increased by its duration. I then tried in vain all the means, cataplasms, frictions, inunctions of oil, to favor the movements which I daily attempted; slight movements availed nothing; the use of greater force brought on swelling and pain, and had to be abandoned. Finally, after a whole month of attempts and sufferings, the patient, although firm and courageous, was unwilling to persevere; preferring to retain his crippled hand rather than undergo the cruel pain of a treatment the result of which I could not guarantee.

Hence the surgeon, as soon as the apparatus is taken off, should move the joints, forcing those which are stiff, and advise the patient

to continually exercise them in this way. Next day, and the days following, he should keep it up, until the articulations have recovered their full freedom.

Lastly, patients often complain of pain and a feeling of weakness at the seat of fracture; we should then be cautious in making forcible motion, and in bringing the weight of the body to bear on the limb; for almost always this pain indicates a yet incomplete callus. From neglecting this sign, the callus has been more than once distorted, the fragments separated or overlapped, and an unexpected mobility brought on. But in such a case, strictly speaking, the fracture has not yet arrived at the period of convalescence, and these hindrances to consolidation require to be discussed separately.

§ XIII.—*Of Hindrances to Consolidation.*

Between a simple delay in consolidation of the callus and the establishment of a pseudarthrosis there is, as we have already had occasion to remark, an essential difference; unhappily the diagnosis between these two conditions, always difficult, is sometimes impossible; indeed, the surgeon can only be safely guided by the length of time which has elapsed since the fracture, and the inefficiency of rational treatment.

Hence we see the importance of knowing and using these means, since for want of them the most expert surgeons have more than once diagnosed pseudarthrosis, and been led to perform operations which were, to say the least, unnecessary. I do not deny that there is something arbitrary in classing as cases of simple delayed union all those which have been curable without operations, and thus to circumscribe pseudarthrosis by the necessity of resorting to such measures; nor would this accord with generally received ideas. But, I repeat, the difficulty of the diagnosis is such that it has not seemed to me to be otherwise soluble; and moreover, I believe that this view is of real utility in practice.

When, therefore, a fracture does not become united in the usual time, the surgeon should first of all seek for the reason, in order to combat it directly. He will therefore inquire if the patient has had a due amount of nourishment. If necessary, he will recommend change of air; and even guard against any morbid moral condition; Marrigues reports the case of a peasant in whom the only cause of delay seemed to be chagrin at finding himself in a hospital. The same author observed, in a young man aged 18, the callus retarded for over eight months by repeated masturbation, and only succeeded in effecting a cure by having him closely watched; and M. A. Thierry has related two analogous cases.* We are to address remedies, if

* Marrigues, *Diss. sur la formation et les différ. vices du cal*, Paris, 1783; A. Thierry, *Expérience*, Nov. 4, 1841.

necessary, to scurvy, syphilis, or any general affection which may interfere with union. The state of pregnancy calls only for patient waiting, and for the most generous diet possible; if the woman is nursing, the child must be taken from the breast.

It is important also to remedy local affections, whether of the soft parts, as œdema, local scurvy, or ulcers; or of the fragments themselves, as exostosis, caries, necrosis, hydatids, etc. Sometimes the evil is undoubtedly incurable, and we are obliged to amputate; but we must not give up too soon. A young man eighteen or twenty years of age had caries of the middle portion of the tibia; a fracture occurred at this part. J. L. Petit removed the fungous granulations, took away some of the carious bone with a trephine, and applied the actual cautery to the remainder; the result was a good cicatrix. Hydatids would perhaps be a graver complication, to judge at least from the one case given by Dupuytren. It concerned a fracture of the humerus in a man of twenty-three; at the end of eleven months, the callus being still unformed, Dupuytren resolved to resect the broken ends. The upper one was resected first; on examining the other, the operator was amazed to find it dilated into a kind of pouch, within which existed a prodigious number of hydatids; these were extracted as far as possible. Resection of this fragment was not performed; the suppuration went on, and the patient having succumbed, this portion of the bone presented a vast cavity without any trace of marrow or of medullary membrane. It is easily seen that under such circumstances the chances of union would be much diminished, and that at least it would be necessary to resect a very large part of bones thus altered.

But it is infinitely more common for union to be delayed, either from the obliquity of the fracture and the separation of the ends, or because rest is not sufficiently maintained; or, lastly, by excessive moistening, by too tight or too early bandaging, or by dressings kept on too long, the atrophied or œdematous limb having lost the vigor essential to the restoration of the bone. From these various circumstances there arise naturally various indications, which may be arranged under four heads: (1) *to insure for a sufficient length of time the immobility of the limb;* (2) *to keep the fragments together by compression;* (3) *to excite the vitality of the part by local means;* (4) *to act, if necessary, on the system at large.*

The first indication calls imperatively for the application of firm dressings, liable neither to relaxation nor to derangement; we should in these cases discard all cushions, slings and boards. Good strong splints, and an apparatus properly solidified with white of eggs, starch, or dextrine; plaster moulds; permanent extension rigorously maintained, and if necessary, cuirasses to confine at once the trunk and the limb; these are our safest resources. If the limb seems sound, and sufficiently vitalised, and if the delay of union has no other

cause than the insufficiency of the external applications used, the immovable apparatus will be effectual; and nowhere, perhaps, is it so clearly called for. The case is quite otherwise when the atrophied or œdematous tissues require the salutary influence of the air and light; splints retained in place by strips of lead-plaster are then far preferable. Ununited fractures of the femur or humerus sometimes render necessary an immobility of the trunk, only to be derived from permanent extension or from cuirasses, and then we should not hesitate to resort to these. The successes thus obtained are so frequent that any surgeon can cite them; but I would add that there would be still fewer failures if we had more perseverance.

A young man of nineteen or twenty was treated at La Charité for fracture near the middle of the femur; at the end of four months the fragments were still very movable. The consulting surgeons proposed various operations, but were generally agreed that a false joint was inevitable, and that the patient must remain crippled. At the earnest entreaty of the uncle of the young man, Boyer undertook the case; he adapted continued extension to the ordinary bandage, which he carefully examined and tightened daily; and at the end of three months of this treatment, the fracture was firmly united.

A painter, thirty-two years old, broke both thighs by a fall. He was treated at the Hôtel-Dieu at Lyons, by splints and permanent extension, but no callus formed, and on the ninety-sixth day there was still the most complete mobility between the fragments. M. Bonnet resorted to the starch-bandage with flexible splints. This apparatus being taken off at the end of two months, consolidation was no more advanced than before. The patient was now placed in the *grande cuirasse* of M. Bonnet, confining at once the trunk and both the lower limbs. About fifty days afterwards, the fracture of the right thigh was consolidated; that of the left did not unite till three months and a half later, the apparatus having been so altered as to make the compression more exact. This very tardy cure only shows how much perseverance will do for both surgeon and patient.

Another account given by M. Bonnet, regarding a fracture of the humerus, is no less encouraging and instructive. A child eleven years old had the arm crushed by a wagon running over it, immediately below the insertion of the pectoralis major. A good many splinters came away, and the fistulous openings closed; but after six months' steady use of splints, the fragments were still entirely movable. The starched bandage was now applied for six weeks with no better success. M. Bonnet then tried his cuirass, which was kept on for about three months, and at last effected consolidation.*

In one of these cases it was necessary to employ a certain degree of compression, but only in order to insure the absolute immobility

* Bonnet, *Mém. cité, Gaz. Médicale*, Sept., 1839.

of the fragments. It is with another view that Amesbury has extolled local pressure; according to his theory immobility is doubtless indispensable, but another no less essential condition is a sufficient excitation of the parts; and it is this excitation which he mainly aims at in making pressure, procuring at the same time also the absorption of the fibrous substance developed between the fragments.

Amesbury obtained this pressure in several ways. Most commonly he made it transversely, either by tightening a little more his ordinary apparatus, composed of splints held together by straps and buckles, or by adding to it, as accessory, a sort of tourniquet worked by a screw. Sometimes also he judged it necessary to push the fragments together endwise; for example in the humerus, by raising the elbow with a short sling; in the leg, by means of a strap going round the sole of the foot and buckled to a brace above the knee. Dr. Wright, of Baltimore, U. S., sometimes used with success simple compresses, sometimes short pasteboard splints arranged around the fracture and held in place by a roller.* His most marked success was in a case of fracture of the tibia of fourteen weeks' standing. But Amesbury gives sixteen observations of fractures of the forearm, leg, humerus, and femur, of from two to sixteen months' standing, consolidated by means of pressure in from three to ten weeks.

He has however met with two cases in which it failed; one a fracture of the humerus, the other of the femur. In these two patients, the mobility was extreme; the arm bent at the seat of fracture with as much facility as at the elbow, and the fragments of the femur could be freely separated in all directions. The author thinks that in such cases as these, there is formed between the fragments an artificial capsule filled with synovia; but this needs proof. Still, however this may be, the obstinacy of these excessively movable fractures is an important fact in respect both to our treatment and to our prognosis.

[In an article published in the *Am. Journ. of the Med. Sciences* for Jan., 1855, Dr. Henry H. Smith, of Philadelphia, proposed remedying pseudarthrosis by means of a sort of artificial support, adapted to the limb in such a way as at the same time to render the fragments immovable and to enable the patient to make some use of the limb; details of seven cases successfully treated by this method are there presented.]

As has been seen, Amesbury endeavored to keep the fragments together, and also to obtain the absorption of the intermediate fibrous tissue; but he thought also to induce a new super-excitation, and hence he carried the pressure so far as even to cause pain. This latter idea has almost always prevailed among practitioners, and to

* Wright, *Remarques sur la réunion des os fract., Journal des Progrès*, tome xv, p. 88.

it are due all the operations of which we shall hereafter speak. To it also are due the trials of the more innocent local applications, which are not always without efficacy; such as stimulating lotions, vesications, the actual cautery, and electricity.

M. Jobert, struck like many other surgeons with the delay of consolidation induced by bandages either too tightly applied or excluding the air too completely, has sought to remedy their effects by reducing the apparatus to a splint loosely confined by a few circular turns at its extremities merely, and moistening the limb with camphorated brandy or a vinous decoction of red roses; and in this way he has obtained solid union in fractures of more than four months' standing.* This is precisely the treatment recommended by M. J. Cloquet for local scurvy. Buchanan, in 1828, tried with some success the tincture of iodine, applied daily over the seat of fracture by means of a small hair-pencil; and others, following his example, have likewise found reason to be satisfied with it.

Vesication was proposed by Walker, of Oxford, in 1815. He used small blisters five or six times repeated, and Brodie states that he has derived very good results from them even in pretty old fractures.† Hartshorne, of Philadelphia, tried cauterisation with caustic potassa, in 1805, with complete success in two cases, and partial success in a third.‡ Birch, of London, has tried electricity, and twice with apparent success; but Mott, imitating him in two cases, used the most powerful charges without effect.

Lastly, it has been thought, and doubtless correctly, that the general condition of the economy might have some influence upon consolidation, and recourse has been had to bitters, to quinine, and, even without any symptoms of scurvy appearing, to anti-scorbutic wine. Saucerotte relates a case of delayed union, which he says was at length brought about by the use of a decoction of madder.§ Fabricius Hildanus recommends strongly the employment of the stone *osteocolla*, either in powder, in wine or in tisane. Paré ridiculed the use of this substance, and some may be surprised to see it mentioned seriously here. We must, however, observe that the facts related by Fabricius bear the impress neither of lively enthusiasm nor of blind credulity. I do not know what was the exact nature of this stone; Fabricius merely remarks that it is soft, friable, *bituminous*, soluble in water, becoming hard and losing its properties by exposure to the air. It is singular enough that in the time of Rhazes, Albugerig recommended, to soothe pain and hasten

* Fleury, *Quelques consid. sur les causes qui peuvent retarder ou empêcher la consolid. des fractures, Archiv. de Médecine*, Aug., 1837.

† *Journal Général de Médecine*, tome ii, p. 340. See also for all the English and American observations, etc., Norris's memoir, already quoted.

‡ [*Eclectic Repertory*, vol. iii, p. 114; Phila., 1813.]

§ Saucerotte, *Mél. de Chirurgie*, 1801, p. 418.

consolidation, the internal use of a sort of natural bitumen called *mumia*, which Avicenna also mentions as an admirable remedy. Without claiming for them any specific virtue, perhaps medicaments of this kind may have a stimulating action not to be undervalued. I once gave tar-water to a woman who had a fracture of the leg which was very slow to unite. The callus at last formed; I cannot say how far it was owing to the tar-water, but I should ascribe at least as much efficiency to it as to a tisane of madder, or any other bitter drink.

But there remains to be mentioned one other internal remedy, the efficacy of which is sometimes most remarkable,—mercury given to salivation. I do not refer to cases such as those narrated by Ravaton and Swediaur, in which the previous existence of syphilis calls for specific treatment. After having obtained some analogous successes, Fleury, one of my teachers, and surgeon-major at Val-de-Grâce, recommended mercurial salivation in all cases of retarded consolidation, saying that it acted by *metasyncrisis*. [Restoration of the normal atomic composition of the system, altered by disease.] It would seem that for some years mercury has had its supporters in England, even in cases exempt from any suspicion of syphilis. In 1830, according to Norris, Sir Stephen L. Hammick spoke highly of its use in either large or small doses, according to the necessities of the case; Collis twice succeeded with it; B. Cooper has given an account of a woman aged 28, having a fracture of the humerus of six months' standing, treated in vain by compression, the seton, the albuminated and the plaster apparatus, and finally cured in one month under the influence of mercurial salivation.* It must however be added that this remedy may, like others, fail; Arnott and Ch. Hawkins have tried it without success.

§ XIV.—*Of Operations for the Cure of Pseudarthrosis.*

For a long time the only operation for pseudarthrosis known in surgery was that extolled by Celsus, the rubbing together of the fragments; and it was not till 1760 that other methods were introduced. We shall study them in the following order: (1) *rubbing the fragments together;* (2) *needles;* (3) the *seton;* (4) the *ligature;* (5) *resection;* (6) *abrasion* or *scraping the ends;* (7) *cauterisation.*

(1.) *Rubbing the fragments together.*—"If the fracture be an old one," says Celsus, "the limb should be stretched so as to break up the new tissue; the fragments should then be separated with the hands, and rubbed one upon the other, in order to make their surfaces rough, to destroy their polish, to reduce everything as it were to the recent state; but great care must be taken not to injure either the nerves or the muscles."

* *Guy's Hospital Reports*, 1837, p. 399.

This plan, although much spoken of, has been very seldom put in practice.* The first instance I know of was published by Bonn in 1783, and since then we hardly find ten reported, although among these the majority were successful. The two following cases will give an idea of the variety of modes in which the method may be applied:

A man aged 44 had had his leg broken by the kick of a horse; the apparatus used having been inefficient, he had still, at the end of six months, no union, and a notable degree of overlapping. Derrecagaix arranged, below the knee and above the malleoli, two strong leather collars with rings at the sides to receive bands; the upper pair of these bands were attached at the head of the bed, the lower to a tackle for extension; this latter was pulled on by three assistants, developing really an enormous power. The leg being brought to its normal length, the surgeon rubbed the fractured surfaces very forcibly together; after which he applied a bandage with adhesive splints, supported by large splints. *The fever*, he adds, *was not high, nor the pain considerable.* By the fortieth day the leg was firm enough for the patient to raise it without any apparatus, and in less than three months he walked without crutch or stick.†

A man aged 30 had arrived at the ninetieth day of a fracture of the humerus, without any union. Without previously making any extension, Kirkbride rubbed the ends of the bone together with considerable force for some minutes. This having caused no pain, it was repeated every day for a week; the parts having now become somewhat sensitive, during the following week the rubbing was performed only every two days; afterwards splints were applied. A month more, and union was far advanced; at the end of the second month it was complete.‡

Another mode of treatment, compared by its own author to that of Celsus, was devised by White in 1768. A farmer, forty or fifty years old, had a fracture of the thigh of six months' standing, which refused to unite. White enveloped the thigh in a laced leather sheath, reaching from the pelvis to the condyles of the femur, and firm enough to keep the bone straight; he then made the patient walk with crutches. In less than two months the callus had begun to form; one month later it was solid; and it was unaffected by a large abscess which occurred in the thigh.

Although the very occurrence of this abscess would seem calculated

* In a memoir, addressed to the Academy of Surgery in 1763, Legrand of Arles reports three cases of non-union, for which he had known of no treatment. In 1780, Sue communicated to the same body some other cases nearly as much wanting in respect to treatment. See the *Clinique* of Desault, by Cassius, tome ii, p. 312.

† *Journal de Médecine*, by Corvisart, etc., tome i, p. 202.

‡ *Am. Journal of the Med. Sciences*, Feb., 1835.

to discourage White in his practice, he has been imitated by several surgeons. According to S. Cooper, in his reports of some cases of non-union of fractures of the leg and thigh, J. Hunter recommended making the patient rise and try to walk, the limb being surrounded with splints, in order to produce the necessary degree of irritation. Sir Everard Home and Inglis, in England; Kluge, in Germany; Champion and Jacquier, in France, have also had remarkable success with this plan. It does not however follow that this means should be suitable in all cases. To say no more of the abscess in White's patient, Sue has related the case of a man with pseudarthrosis in the femur, for whom Perron, at about the same time as White, had a sort of thigh-piece made; but this hindered the circulation so much, and caused so much pain when the fragments rubbed one against the other, that it could not be endured.*

On the whole, however, we see that the successful applications of this method in the lower extremity are quite numerous. Something similar has been tried in the upper extremity; but here of course the effect would be simply that of compression, without the mutual rubbing of the broken ends, caused in the leg or thigh by the weight of the body, and by walking; so that failure has often ensued. Briot relates that, for two cases of fracture of the humerus, with loss of substance and delayed union, occurring in soldiers, he had two pairs of semicylinders constructed of sheet-iron; each pair was stuffed on the inside, and completely surrounded the arm, being confined to it by bands tightened at will by the patient. He had in view only the external support of the arm; in one of his patients he obtained a kind of callus. He prescribed a similar apparatus for a fracture of the forearm; but consolidation did not occur. More recently, Baillif, of Berlin, constructed something almost exactly like this for two patients sent to him, one by Kluge and the other by Rust; one, with a fracture of the arm, was not cured; in the other, who had a fracture of the forearm, three months sufficed for complete union.†

(2.) *Needles.*—In 1837, I tried to introduce acupuncture needles between the un-united ends of a fracture at the inferior fourth of the femur; but although movable, the fragments were so close together that of thirty-six needles entered at different points, I could not make one pass between them. M. Wiesel succeeded better in a fracture of the forearm nine weeks old. He first passed between the fragments of the ulna two needles long enough to go entirely through

* White. *Cases in Surgery*, 1770, p. 75; *Hunter's Complete Works*, translated into French, vol. i, p. 561; Inglis, *Observ. on the Cure of Unnatural Articulations*, etc.; *Edinb. Med. and Surg. Journal*, 1805, vol. i, p. 419; *Journal des Progrès*, tome x, p. 258; Velpeau, *Médecine Opératoire*, second ed., tome ii, p. 583; Sue, *Obs. et Réflexions*, etc., in the *Clinique* of Desault, tome ii, p. 312.

† Briot, *Hist. de la Chir. Militaire en France*, etc., 1817, p. 411; *Journal des Progrès*, tome x, p. 259.

the false joint; they were allowed to remain for six days, and then removed, their presence having brought on considerable pain and swelling. Five days later, the same was done with the radius. A simple bandage was applied, and in the space of six weeks consolidation was complete.*

(3.) The *Seton.*—A. L. Richter dates the conception of this plan as far back as 1787, attributing it to Winslow, on the authority of a Danish journal which I have not been enabled to consult. It would appear also that Percy attempted it in 1799, but rather to procure the elimination of some adherent splinters than directly to induce consolidation;† and Dr. Physick, of Philadelphia, who in 1802 used the seton in a case of actual pseudarthrosis, should be regarded as the author of this method. Since that time, the seton has been employed by many surgeons, in various modes and with various results.

The first operation of Dr. Physick was a very simple one. Having a fracture of the humerus to deal with, he caused extension to be made so as to put the fragments in relation, and then passed between them a seton-needle armed with a silk ribbon, carefully avoiding the course of the vessels, and choosing for the points of entry and exit the least fleshy parts of the arm. This seton was kept in for five whole months, and only withdrawn when consolidation was completed.

In the thigh, it would be difficult so to pass the seton without having previously exposed the fracture by an incision; and Norris mentions such an operation, performed by Physick himself in February, 1810. I do not know that he had been anticipated in this, which seems to have been imitated by several surgeons. We may derive a just idea of it from the following summary of one of Wardrop's cases.

The fracture, of twenty months' standing, was seated three and a third inches below the great trochanter, and the shortening amounted to three and a third inches. Owing to the patient's fleshiness, the exact state of things could not be ascertained; the upper fragment could be very well traced throughout, under the rectus muscle; the inferior was buried in the tissues; but their connection was so loose that moderate extension brought down the thigh to its normal length. Wardrop made an incision of nearly two inches along the outer edge of the rectus muscle, just over the upper fragment, which was thus exposed. The forefinger being passed in by this wound, served as a director upon which to divide with a probe-pointed bistoury the soft parts still concealing the lower fragment. The finger having at length reached the fibro-cartilaginous substances lying between the two ends, the operator carried in first the blunt sheath of the seton-

* *Journal de Chirurgie*, 1844, p. 85.
† Laroche, *Thèse inaug.*, Paris, an xiii.

needle, and having well determined the point of introduction, pushed the needle itself through this intermediate tissue, downward and outward, so as to make it emerge below the vastus externus muscle. The seton was then drawn through; but before the apparatus could be put on, a jet of arterial blood appeared at the upper wound. It came from the bottom of the wound, and the surgeon was obliged to carry in his finger, and thus to compress between the thumb and forefinger the soft parts at the outside of the thigh for more than half an hour. The bleeding being at last arrested, permanent extension was tried, but the patient could not endure it. Eight days after, it was attempted again, but had to be again given up; and ordinary splints were used. The seton was withdrawn on the twenty-first day, and consolidation seemed going on well, when two successive attacks of erysipelas destroyed twice the newly-formed callus. On the whole, the success was very incomplete, the thigh not acquiring firmness enough to support the weight of the body.*

We see that besides the incision, Wardrop's plan differs from Physick's in the much earlier removal of the seton; the latter commonly leaving it in place four or five months, or even more; the former being satisfied with some weeks, and even in one case removing it at the end of eight days. Moreover, the length of time for the seton to remain in seems to be almost entirely optional; in some cases it was left for one, two or three weeks; in others one, two, three, four or five months; Liston mentions one in which he kept it in for thirteen months.

Norris has examined the results of this method, independently of its special modifications; and has deduced a statistical table comprising forty-six cases. His summary is very incomplete; for placing together only the cases mentioned in his own memoir I find seventy-two cases, as follows:

30	fractures	of	the	humerus	- - - - - - -	13	cures,	16	failures,	1 death.
18	"	"		femur	- - - - - - - -	9	"	8	"	1 "
14	"	"		leg or tibia alone	- - - -	13	"	1	"	0 "
6	"	"		forearm, or one of its bones,		6	"	0	"	0 "
2	"	"		clavicle	- - - - - - -	2	"	0	"	0 "
1	"	"		lower jaw	- - - - - - -	1	"	0	"	0 "
1	"	"		acromion	- - - - - - -	0	"	0	"	1 "

We may derive some useful information from this table; we see how much more readily false joints may be cured in the forearm and leg than in the humerus and thigh. But what effect has each mode on these results?

The previous incision would seem to have nothing to do with the ultimate result; of twenty-one thus operated on, Norris gives seventeen cures and one death; of twenty-four treated without it,

* *Medico-Chir. Transactions*, vol. v, p. 358.

eighteen cures and one death. It is however better to employ the needle alone, when we can direct it with certainty.

A more important question is as to how long we should keep the seton in. We cannot here establish a parallel between two methods merely, since in this respect surgeons have adopted such very different views; I have however collected some facts which may throw light on the question. Liston, who advises the removal of the seton on the eighth or tenth day, has thus treated successfully a fracture of the forearm.* Others have succeeded in cases of fracture of the leg by leaving the seton in from twelve to fifteen days. To be sure, these varieties of fracture yield more readily than others; and it is mainly between those of the humerus and femur that the comparison is of interest. Now, let us see how the case stands:

Seton kept in for—	Fractures Treated.	Results.
8 to 10 days,	3 of the humerus,	2 cures.
	1 " " femur,	1 "
13 to 14 days,	2 " " "	2 "
22 to 30 days,	2 " " humerus,	1 "
	2 " " femur,	neither cured.
2 to 13 months,	6 " " humerus,	3 cures.
	4 " " femur,	3 "

To sum up, the seton retained one or two weeks has given, in six cases, five cures; and from three weeks to thirteen months, in fourteen cases, seven cures. Although the smallness of these numbers forbids the drawing of a rigorous conclusion from them, we must still be struck with such results.

The seton, like the needles, cannot always be inserted between the broken ends; this fact has given rise to another plan which merits serious attention. Oppenheim recommends in such cases the passing of two setons, one from one side and the other from the other side, close to the extremity of each fragment, and their withdrawal as soon as suppuration is established; he has in this manner procured consolidation in the humerus, and also in the forearm. Saurer, in 1833, passed a seton around a fracture of the tibia, in the following manner. He made an incision on the outer and one on the inner side of the bone; and from one to the other he passed, beneath the bone, a seton-needle half an inch wide and a little curved. There was considerable inflammation and suppuration; the seton was withdrawn on the tenth day; and three months afterwards the patient was able to resume his work in the field.†

[In May, 1851, Dr. Peace passed a seton for ununited fracture of the femur, occurring in a laborer, at the Pennsylvania Hospital. The man had had syphilis; the fracture had occurred nine months previously. The seton was passed from before backward; it re-

* Liston, *Practical Surgery*, third edition, 1840, p. 100; Norris, *loc. cit.*
† Norris, *loc. cit.*

mained in place three weeks, when the patient was attacked with pyæmia, and died. The operation is not a favorite one in this country.]

These results are calculated to excite the attention of surgeons. The object of the seton being to produce sufficient inflammation around the fragments, does not Oppenheim's plan more directly accomplish this object than Physick's does? We shall resume this question directly.

(4.) The *Ligature.* Between the seton and the ligature there is a good deal of similarity; the latter however is peculiar in being intended gradually to divide the fibrous tissue between the fragments.

Sommé, of Antwerp, first conceived of this plan. He had occasion to treat an oblique fracture of the left femur, with overlapping of the fragments, the lower going inward and the upper outward. "The patient being laid on his back and firmly held, I thrust in," says this author, "a long trocar and canula, first below, at the inner side of the upper fragment, making it come out posteriorly a little to the outer side; the trocar was then withdrawn, and a silver wire carried through the canula as far as the posterior opening. The canula being now in its turn withdrawn, was readjusted over the trocar; the whole was again entered above and at the outer side of the lower fragment, and brought out at the same orifice posteriorly as before. The trocar being again removed, the anterior end of the silver wire was carried through the canula, so that both ends of the wire were together posteriorly, and a loop of it left in front. Then laying in one by an incision the two orifices made anteriorly by the trocar, and drawing on the two ends of the wire, I brought the loop between the fragments, and closed the incision through the skin by an agglutinative plaster." The limb was placed in a fracture-box, and at each dressing the ends of the wire were drawn upon, so as to bury the loop more deeply in the tissues. No bad symptoms occurred. The operation was performed August 12, 1828; six weeks afterwards, union was plainly perceived; the wire was however left in place till October 2. The apparatus was kept on till the middle of November; and the patient is even said to have recovered without any shortening.*

It was in fact a ligature also which Seerig used under the name of a seton, and this is the more clear from the circumstance that he used with it the *serre-nœud.* In his first patient the fracture was at about the middle of the tibia. Two longitudinal incisions two inches in length were made, one at each side of the tibia, parallel to it; an S-shaped needle armed with a mesh of twelve threads, was then carried around the pseudarthrosis, first from behind forward and from within outward, afterwards from before backward and from without

* *Medico-Chir. Transactions,* 1830, vol. xvi, p. 36.

inward; the two ends of the mesh were fastened by the *serre-nœud* of Graefe.* In the evening of the same day there came on violent fever, with swelling and severe pain in the limb. Suppuration was soon established; the ligature, which was tightened anew every day, came away on the sixth; at the end of a month the external wounds had cicatrised, and in fifteen days more, union was complete.

It should be said that the fracture in this case was of only four months' standing. In a fracture of the femur, two years old, the ligature failed, and resection was decided upon as the only proper resource.†

(5.) *Resection.*—Invented by White, in 1760, this was first practised in the following case.

A boy, nine years old, had had the humerus fractured at its middle, six months before; amputation had been recommended. White proposed to make a longitudinal incision at about the external and lower margin of the deltoid, to turn out first one and then the other of the fragments, which would be easy from their mobility, and resect them with a saw or with cutting forceps; and to treat the case subsequently as one of compound fracture. The operation was performed by an expert surgeon; the patient did not lose a spoonful of blood; and the wound was nearly healed at the end of fifteen days, when erysipelas came on to delay the cure. However, six weeks after the operation, the callus began to form, and was soon ossified.

In 1769, White had another case of pseudarthrosis to treat, this time affecting the tibia, with overlapping. The fibula being partly united, it was not possible to turn out the fragments as in the case of the humerus; the operation had therefore to be modified. White made a longitudinal incision about three and a half inches long, and exposed the end of the upper fragment, which was somewhat pointed, and covered with a white cartilaginoid mass, but showed no trace of callus; by means of a very large trephine, he easily effected the resection. The lower fragment was now more exposed than before; and as it could not be resected without much pain, difficulty and danger, White contented himself with scraping the periosteum covering it; he then filled the wound with dry charpie, and applied splints. The ensuing inflammation was but slight. The wound was kept dilated either with sponge or with charpie. About the eighth day, White removed with cutting forceps a point of bone left by the trephine, and touched the lower end with butter of antimony. He likewise applied this caustic between the two fragments, so as to

* [A metallic stem with an oblique perforation at one end; through this are passed both ends of a thread, to be fastened to a screw which runs into the other end of the stem; the bight or loop thus left at the extremity of the stem will of course be drawn in or let out as the screw is turned one way or the other.]

† *Archives Générales de Médecine*, Jan., 1839.

destroy the tissue preventing their immediate contact; this operation was repeated three or four times at suitable intervals. There followed some slight exfoliation, after which the progress of the cure was uninterrupted. Nine weeks after the operation, the patient could walk with a stick; at the end of twelve weeks the wound was entirely cicatrised and the consolidation complete.*

It will be observed that White did not leave much to be done by his successors. Resection of both fragments and of one alone, scraping of the periosteum, cauterisation, each of these was tried by him successively. Wardrop, in 1802, applied resection in the forearm; Rowland, in 1806, to a fracture of the femur, and both these cases were successful. We find a great many such attempts, but fortunate results are by no means equally frequent. In order to determine the proportion of the successes and failures, Norris has compared only thirty-eight cases, even including some of mere scraping of the bone. I have thrown out these cases; and collecting all those mentioned in Norris's memoir, have made up a total of sixty-two operations, in which resection has been performed on one bone or on both fragments; they are as follows:

27	fractures of the humerus	-	-	-	-	11	cures,	14	failures,	2	deaths.
17	" " femur	-	-	-	-	10	"	3	"	4	"
9	" of one or both bones of forearm	-				7	"	2	"	0	"
8	" of the leg or tibia alone	-	-	-		8	"	0	"	0	"
1	" " jaw	-	-	-	-	1	"	0	"	0	"

In the leg and forearm, the results seem as satisfactory as those from the use of the seton; in the humerus, the proportion of cures is nearly the same, but there are two deaths instead of one; it is however in the femur especially that we begin to get at the truth of the matter. The cures cover more than half the cases; but the deaths comprise nearly a quarter; and we must remember besides, that these tables, derived from observations published here and there, would show but a very small proportion of the actual number of failures.

On the whole, although sometimes successful, resection is always a serious operation, and one which in the thigh and forearm, where there is but a single bone, involves at least as much danger as an amputation would. All surgeons are agreed as to the difficulties surrounding it; in the thigh especially, we should read the reports of cases to obtain a correct idea of them. Rowland was obliged to make an incision seven inches long, and to cut across a great part of the vastus internus muscle. He states that the operation exceeds in difficulty all that he had ever seen or performed, and that he has doubts about recommending it to others. In a case reported by Vallet, it occupied an hour; and the patient died in convulsions on

* White, *Cases in Surgery*, pp. 69 and 79.

the same day. In a patient operated on by Hewson, the time required was still longer; according to Norris it was nearly two hours.* Even in the humerus, it is by no means always easy; and frequently after it is accomplished the surgeon encounters great difficulty in the coaptation of the ends of the bone. In a patient operated on by Boyer, they were separated by an interval of nearly two inches; and in order to bring them together the elbow had to be supported by a special apparatus. M. Flaubert has seen them not only separated by a wide interval, but also displaced laterally, the upper backward and outward, the lower inward and forward. This difficulty has struck several operators; and Boyer's bandage not being sufficiently certain in its effects, other means have been devised.

In a young girl whose humerus he had resected, M. Roux inserted the point of one of the fragments in the medullary cavity of the other; no bad symptoms ensued; but unhappily, at the end of two months, a fall on the arm undid the whole of the treatment, and subsequently amputation became necessary.† A surgeon, whose name is not given, conceived the idea of making the fragments hold together by shaping their ends into a sort of mortise and tenon; but the attempt failed, and the ends soon became loose again.‡ Lastly, Dr. Kearney Rodgers, [of New York,] in 1825, and subsequently M. Flaubert, of Rouen, resorted to a means the solidity of which cannot be questioned, viz., the *suture* of the fragments.

Rodgers first tried it in a young man of fifteen, who had a fracture of the humerus of seven months' standing. The fragments being resected, and still not coming together, he made a hole near the extremity in each, penetrating into the medullary canal; then through both holes he passed a silver wire, bringing its two ends through a canula which he left lying in the wound. On the sixteenth day the canula came away, and with it the wire loop; on the sixty-ninth day consolidation was complete.

Mott, in 1831, obtained a similar result in the humerus; Cheeseman, in the humerus and femur; and afterwards Rodgers, in the radius. Their operations are described as above, but in the later trials the canula was dispensed with, the two ends of the wire being merely twisted together and left in the wound.§

[Dr. N. R. Smith of Baltimore has twice done this operation successfully in the femur. In one case four gold wires were used, and the patient walked to Dr. S.'s office to have the last one removed.]

* Vallet, *Thèse inaug.*, Strasbourg, 1817, (quoted by Velpeau;) Kirkbride, *Reports of five cases of ununited fracture, Amer. Journal of the Med. Sciences*, Nov., 1835. This paper was partially translated in the *Archiv. Gén. de Médecine* for Feb., 1836.

† A. Bérard, *op. cit.*, p. 53.

‡ Laloy, *De la suture des os*, etc., *Thèse inaug.*, Paris, 1839.

§ J. Heard, *Report of Cases of Ununited Fracture, New York Journal of Medicine and Surgery*, Oct. 1839.

M. Flaubert's operation, dating back only to 1838, was done in a manner somewhat different. The resection being accomplished, the surgeon bored with a gimlet the external face of each fragment at about one-eighth of an inch from its extremity, the gimlet being directed obliquely toward this extremity; then with an ordinary needle, a simple thread was passed through both holes, and by means of this there was drawn through a more solid ligature composed of four strands of waxed thread; this latter, tightened and knotted in the usual manner, insured a very exact apposition. The subsequent course of this case was in no way peculiar; on the twentieth day the ligature came away, bringing with it a small lamella of necrosed bone; consolidation however did not occur, and the patient was obliged afterwards to wear a leather brace to give solidity to the arm.*

M. Flaubert has since imagined that the chances of success would be increased by sawing each fragment obliquely, so as to make them correspond by a larger amount of surface; an idea which might be tested, not only with the suture but also with the ligature.

I do not think there is much difference between the resection of both fragments and that of one alone; the consequences are the same, and it is to be remarked that from White to Dupuytren, it was the difficulty or impossibility of resecting the second fragment, which has limited the operation to the first. Dupuytren's principle on this point is no more peculiar than his operation.

(6.) The *rubbing together* of the broken ends was at first merely an expedient of White's, as a substitute for the resection of the second fragment. Some surgeons would make of this a separate plan, rubbing the ends together in place of excising them. It is a kind of incomplete resection, which doubtless makes the operative procedure an easier one, but which seems not much less dangerous than resection properly so called. White, of New York, resorted to it in 1816, for a fracture of the tibia two years old; he obtained union at the end of three months. Vincent, of London, tried it in a fracture of the forearm; his patient died on the fifth day. Brodie, in 1835, practised it for a fracture of the leg in a boy five years old; he failed. To these attempts must be added that of Viricel, who passed a seton through a pseudarthrosis of the femur, having previously filed up with a coarse file the opposing surfaces; the patient died some days afterwards.†

John Hunter, starting with the erroneous idea that there was gene-

* Laloy, *op. cit.*

† Norris, *loc. cit.*; Monfalcon, *Mém. sur l'état actuel de la chirurg.*, 1816, p. 195. Barthélemy (*Thèse inaug.*, Montpellier, 1814, p. 21,) also proposed what he called *scarification* of the fragments, by carrying to the bottom of an incision in the soft parts a silver canula, bearing a sort of rasp; I do not know that this was ever actually put in practice.

rally in pseudarthrosis a synovial cavity, asserted that it was enough merely to lay open this cavity and irritate the surfaces. Sir E. Home quoted in his lectures a case of ununited fracture of the humerus, thus treated by Hunter. There was a false joint; Hunter opened it, and introduced a spatula so as to irritate the entire surface. There followed a good deal of inflammation, which resulted in the soldering up of the false joint.* Here, indeed, there was a sort of moderated friction, only applicable in some exceptional cases.

An idea at first sight more attractive was to perform this abrasion with the advantages of the subcutaneous method. "In one case," says Sir C. Bell, "I thought myself warranted, from observations made on animals, in proposing to pass a sharp instrument obliquely in as far as the bone, to penetrate the ends of the fragments. I thought that the wound by which the instrument had entered would soon heal, and at all events that the ends of the bones would be enough irritated to resemble a simple fracture much more nearly than is possible after resection. But perhaps the patient judged more correctly than the surgeon; he would not submit to have it done." Something similar was recently attempted in Paris by M. Blandin; but the result did not meet his expectations.

The patient was a waiter, forty-three years old, healthy, but having had for eighteen months a very oblique fracture at the lower part of the humerus. A fold of the skin on the outer side of the arm being raised up, a narrow bistoury was carried through this fold, down to the bone. Another narrow bistoury, but button-pointed, was now substituted for the first, and carried carefully into the space between the fragments; it was then made to divide the intermediate fibrous tissue, while the operator guarded the brachial artery with his left forefinger. The fibrous layer being divided, the surgeon, turning the edge of the bistoury in various directions against the surfaces of the fragments, rubbed and scraped them as much as possible; after which the puncture, which had bled but a few drops, was closed with a bit of lead-plaster, and the arm dressed with splints and bandages. But on the same day there was felt severe pain in the arm; two or three days afterwards an attack of erysipelas came on; the puncture ulcerated and discharged bloody pus; the opening had to be enlarged, and a second one made on the inner side.†

Might we not, however, hope, by keeping the limb entirely motionless, to avoid any suppuration? It would seem that Biondi, of Bucharest, actually did succeed, by means of the subcutaneous section, in curing a pseudarthrosis; but I have not read his observations, and cannot state the precise circumstances of his good fortune.‡

* *Hunter's Complete Works*, translated into French, tome i, p. 561; *London Med. Gazette*, vol. iii, p. 56.

† *Gazette des Hôpitaux*, 1844, pp. 557 and 569.

‡ *Gazette des Hôpitaux*, 1845, p. 64.

(7.) Lastly, the *cauterisation* of the fragments, another of White's expedients, has been elevated to the dignity of a *method*. According to Norris, it was first tried by Mr. H. Cline, of London, and with success. Earle, in 1821, repeated this course on two patients with pseudarthroses of the humerus; after laying bare the fragments by a long incision exteriorly, he cut through the intermediate fibrous tissue, scratched the ends with the bistoury, and then rubbed them with a stick of caustic potassa until they assumed a black color. He failed in both cases. It appears, however, that both Hewson and Barton succeeded with it in fractures of the leg; Norris himself obtained by means of potassa the consolidation of a humerus fractured four years before. Others have been equally successful with other caustics; thus Lehmann and Weilinger used the butter of antimony, before preferred by White; Ollenroth employed nitric acid, etc.*

After such cauterisations, as might be expected, we should rightly judge exfoliation to be unavoidable. In Earle's first case, two little bits of bone were six weeks in becoming detached; but in the second there were none. Hence it appears that cauterisation does not involve such serious dangers as resection or mere rubbing; but the published cases are too few to enable us to pronounce positively on this point.

There remains one other resource, allied to cauterisation; it is a cauterisation very much mitigated in severity, and also subcutaneous. It is due to M. Mayor.

A young man of twenty-eight had had for six months an ununited oblique fracture of the femur. M. Mayor tried at first rubbing, and also powerful momentary pressure with a tourniquet. This caused considerable swelling around the fragments; but at the end of ten weeks the callus was no more advanced than on the first day. The surgeon then luxated, to use his own word, the joint, so as to slide between the fragments the canula of a very large trocar. Through this metallic canal, which he left in place for eight hours, he passed at different times a rounded iron which had been previously dipped in boiling water. He thus excited severe phlegmonous inflammation; a free exit had to be made for the pus; but at last, in less than three months, the patient could use his limb, and walk with a stick. M. Mayor claims to have since been even more successful in another case.

[In November, 1848, Dieffenbach published in *Casper's Wochenschrift* an account of a new plan for exciting inflammation and promoting the union of fractures, viz., the introduction of ivory pegs into holes previously drilled in the bone. This method was successfully employed by him in a good many cases; in the United States it has been occasionally practised.

* Earle, *Medico-Chir. Transactions*, vol. xii, p. 190, and *Mél. de chirurgie étrangère*, tome i; A. Bérard, *loc. cit.*; Norris, *loc. cit.*

I have seen the mere boring of the bones tried in one case, but the result was negative.]

After this lengthy exposition of methods and processes, we must endeavor to make a well-founded selection, and this is assuredly by no means easy. A comparison of the results obtained sheds light on one side of the question; perhaps the study of nature's occasional processes will tend to still further clear it up. The observations here are rare; we however see the work of consolidation recommenced in two ways. First, from the effect of accidental contusion. A sailor having broken his humerus, the bone showed no tendency to unite for three weeks; but the patient then getting a fall and severely bruising the arm, from that time his recovery was rapid.* Amesbury saw a much more remarkable case. A fracture of the femur remained movable for several months; the patient was thrown from his cabriolet, and the wheel went over his thigh just at the seat of the false joint. Active inflammation ensued, confining him to his bed, and bringing on the union of the broken bone.

The second process is a spontaneous inflammation of the limb. Thus erysipelas, which may destroy the commencing callus, would appear sometimes to revive the action when it languishes. Seerig gives a very curious instance of this. A compound fracture of the humerus just above the condyles remained ununited, and the patient was unwilling to submit to any treatment for it. He was all at once attacked, without any apparent cause, with erysipelas of the limb; and this brought on consolidation.

From this small number of cases, we see that it is an irritation of the soft parts, and not of the bony fragments, which sets up a favorable action. In ordinary normal callus, whence come the materials? From the soft parts. Why, then, attack the broken ends, resect, scrape, and cauterise them? Excepting resection, for which there are special indications to be presently pointed out, such operations are really irrational; they have, indeed, sometimes succeeded, because the bones could not be so disturbed without inducing active inflammation of the soft parts; but this is buying too dearly a result which may be obtained at a less cost.

I think, therefore, it is upon the soft parts that we ought really to work; and following the example of nature, we should first of all excite in them the adhesive inflammation. Stimulating lotions have too slight, vesication too powerful an action; but sinapisms, producing an irritation at once more prompt, more intense and more profound, without the disadvantage of involving suppuration, appear to me to answer a far better purpose. The rubbing of the fragments together acts only by irritating the soft parts; and with the same object we may use also rude and forcible flexions of the fragments

* Wardrop, *loc. cit.*

upon one another, in order to break the connecting fibrous tissue; or a direct and sudden compression, violent enough to contuse the surrounding tissues. Lastly, acupuncture affords us a safe resource, the efficacy of which may be increased by passing electrical currents through the needles.

Thus, we try first to excite adhesive inflammation; when all our means for inducing this have failed, and then only, we resort to suppuration. Here there occurs a question: should we, as some adherents of the seton do, keep it up for whole months, or should we, following Liston's example, withdraw the seton after eight or ten days? To prescribe the long continuance of the seton as the general rule, is actually an absurdity. What is it which retards and interferes with consolidation in compound fractures, if not prolonged suppuration? But on the other hand the term fixed by Liston is too arbitrary; the true rule is to retain the seton or keep up the suppuration just until it has induced the proper degree of engorgement of the soft parts. Eight days may suffice, in some cases; in others fifteen, twenty, or even more, will be necessary. The study of the facts has led us to the same results, and we have seen the seton fail from too early removal as well as from too long continuance.

A second question, quite as important, is whether or no we must establish suppuration between the broken ends, at the very seat of the fracture. Theoretically I see neither necessity nor utility in so doing; and experience has decided the question in the same way, as was proved by Oppenheim. We should add that the seton carried between the fragments, reducing the lesion to the state of the severest form of compound fracture, involves nearly as much danger as resection, and exposes to the same accidents. I will go further; it is a very severe mode of inducing suppuration around a pseudarthrosis, to pierce the part through and through twice with a seton; M. Mayor's cauterisation, attacking the false joint on one side only, will often suffice, and has already received the seal of experience. I believe however that this process could be advantageously simplified, and that it would suffice to make an incision down to the bone, and cauterise it to the bottom with potassa, so as to prevent its healing too readily.

Lastly, in some cases of overlapping of the fragments, and especially when they are loose among the tissues, resection has seemed to me to be the only rational resource, combined with suturing the fragments, which I consider a real step in advance. I have seen three ununited fractures of the femur, of very long standing, which I did not then think of treating, so great was the mobility; having the suture, I should not now hesitate. For the rest, we should not forget that in all operations which expose the fragments, but especially after resection, we have to dread repeated attacks of erysipelas. White's first patient had but one; Kirkbride saw them in all

the cases which he reports, except in one; and in this one it was doubtless for want of time, the patient dying on the sixteenth day. To cite one of the most striking instances, a young man of twenty-six, in whom Harris successfully resected the femur, had erysipelas no less than eight or nine times.

[From the case-books of the New York Hospital, I have obtained the following memoranda of nine cases of non-union, treated in that institution:

No. 1. A man, aged 30. Left humerus broken eight months before. Drilling, rubbing and close contact had been tried. Acupuncture with electricity proved effectual in inducing firm union.

No. 2. A man, aged 24. Left humerus broken four months before. Resection, drilling, a silver wire kept in place for five weeks, and a starched bandage, gave very little relief. He was sent into the country.

No. 3. A little girl. Humerus ununited at the end of four months. The fracture was cut down upon, and a bit of muscle cut away from between the broken ends; lower fragment scraped, and three-quarters of an inch of upper one removed; a silver wire introduced, and kept in for thirteen days. Some relief.

No. 4. A man, aged 36. Right humerus broken eight years before; no union, but some use of the arm by keeping it supported with a leather splint.

No. 5. A man, age unknown, whose right humerus had been broken fifteen years before. Rubbing of the ends, and the seton, had been tried without success; resection was performed, and complete union obtained, although with a shortening of two inches.

No. 6. A man, aged 26. Right radius broken four months and ten days before. Rest and proper position had been tried in vain; resection was performed, and the ends became firmly united.

No. 7. A man, aged 28. Right femur broken nine months before. Resection, and complete consolidation.

No. 8. A man, aged 28. Left femur broken three months before. Rubbing of the ends, Amesbury's splints, exercise, mercury, and the seton having failed, amputation was performed.

No. 9. A man, aged 60. Left femur broken seven months before. Friction, splints, and the immovable apparatus, had no effect. Amputation; fracture oblique, united by ligament.

For a report of thirteen other cases of pseudarthrosis, treated in various ways, see a paper by John Watson, M.D., of New York, in the *New York Medical Times*, vol. i, No. 1, Oct. 1851.]

§ XV.—*Of Secondary or Recurring Fractures.*

Although the immobility of the fragments, the absence of pain at the seat of fracture, and the return of the limb to its functions,

afford unmistakable evidence of consolidation, still, especially for some time, the patient must be very careful; we have seen, in studying the transformations of the callus, that the most compact diaphyses are hardly ever reunited except by spongy tissue, which is of course less solid than that of the rest of the shaft. Sometimes a sudden effort, or the mere weight of the body, is sufficient in fractures of the lower extremity to bend even an old callus; while a direct blow, or a fall, instead of bending may break it.

M. Jacquemin had an opportunity of experimenting with these two processes upon two specimens of callus of a known date. A man, aged 51, had been suddenly carried off by a double pleuro-pneumonia, on the forty-fifth day of a fracture of the thigh. The femur was stripped of the soft parts, and fixed horizontally on a table, so that the callus and the longer fragment projected over the edge; there was then hung at the outer end a scale-pan, in which weights were put and gradually increased. At twenty-eight kilogrammes, [seventy pounds avoirdupois,] the callus bent and curved without any apparent rupture; at thirty, the fragments separated, the callus remaining nearly entire, and attached to the upper portion. An oblique fracture of the humerus at fifty-nine days, similarly treated, first bent and then broke with a weight of less than twenty-eight kilogrammes.*

It is by no means extremely rare to meet with such curvatures in the living subject. Wall has given an account of a carpenter forty-eight years old, who had had an apparatus on for fifty-four days for a simple fracture of the leg; eight days after its removal, contrary to the surgeon's advice, he resumed his occupation; but in the course of fifteen days the bones became so curved as to shorten the leg three-quarters of an inch. Oesterlen saw a young man of nineteen, cured in two months of a fracture of the femur, who was passing at the end of the third month along a slippery place, when he slipped, and felt severe pain, and crepitation, at the seat of fracture; he did not fall, but walked with assistance some twenty steps; the femur was curved outward, but not entirely broken. I have now in my wards a young man of twenty-four, who at the fifty-fourth day of a fracture of the femur, trying to walk, bent the callus so that the two fragments present a very marked angle anteriorly. But the most remarkable case of this kind is that of M. Guillon, who has seen the femur at the one hundred and thirty-fifth day of a simple fracture, in a young girl of sixteen, suddenly bent to an angle in the effort to avoid a fall; it was really a mere curvature, since the patient could still walk on the limb for two days.

In these different cases, we really cannot tell to what should be ascribed this unusual flexibility of the callus; sometimes its cause is

* Jacquemin, *Thèse inaug.*, Paris, 1822, p. 14.

more evident, as in the following case. A man of forty-eight had a fracture of the leg, consolidated in eight weeks in spite of a small abscess; he attended freely to his affairs, when at the middle of the eleventh week the abscess reopened, and both bones bent at the callus.*

Complete rupture of the callus may occur quite as soon after the original fracture, but from somewhat different causes, as was before mentioned. We find in Delamotte two cases of fracture of the leg, which at about the fiftieth day were reproduced by the patients falling while walking with crutches. The same author has likewise seen such ruptures occur much later; for instance, one of the patients just mentioned had been more than three months cured of his second fracture, when he was thrown from his horse, and broke his leg again at the same place. In another case, a young lady, who had been cured two months of a broken leg, fell down stairs and reproduced the fracture.†

Oesterlen has collected ten cases, some of which are exactly similar to those of Delamotte; but the others are still more curious, as showing by experiment what pathological anatomy would enable us to foresee, viz., that months and years may elapse without the callus acquiring the same solidity as the rest of the bone. A man of thirty, eight months after a fracture of the forearm, broke the callus by striking the edge of a table; a child two and a half years old refractured the clavicle after eighteen months; in two other children of from fourteen months to two years, the femur was refractured by falls after three years; and to show that these late recurrences are not confined to children, a man of thirty, who two years before had had his leg broken and cured with a great curvature outward, broke it again at the same spot.‡

[In the *Medical News* for July, 1857, there is mentioned a patient at St. Bartholomew's who has fractured each thigh three times—always by accident, and always at the same place; each time recovering well and with a useful limb.

Jane Savage, aged 28, a domestic servant, was admitted into the Pennsylvania Hospital, June 1, 1853, having tripped in walking, and fractured the left femur two inches above the condyles. For a few days there was much swelling and irritation; she was discharged with a useful limb, September 1. She was readmitted March 31, 1854, having again tripped in walking, with the same result. A tumor now formed about the seat of fracture, gradually increasing till it attained an enormous size, and discharging a thin fluid from one or two openings. The shortening became extreme, the tumor kept involving the

* Oesterlen, *Sur la rupture du cal*, translated into French by Maurer, obs. 31, 33 and 35; Guillon, *Thèse inaug.*, Paris, 1820, p. 14.

† Delamotte, *Traité comp. de chir.*, obs. 371 to 373.

‡ Oesterlen, *op. cit.*, obs. 21 to 30.

bone higher and higher, and amputation was advised. This she would not submit to, and death ensued from exhaustion, July 14, 1855. The tumor was partly cartilaginous and partly bony.

Margaret Newland, aged 87, was admitted into the same institution, August 14, 1853, with a fracture of the right femur at about the junction of the middle and upper third, caused by a boy tripping her up. She had had the same femur broken at the same place twice before. She was discharged by request, after being under treatment eighty-five days; the limb was not yet consolidated.]

It should be added that these latter cases are very rare, and in studying them in detail we see that in all of them there had been union with angular deformity or with notable overlapping. I have myself had to treat a young girl of twenty-one who had, by a fall, broken the femur at the exact spot where it had been broken six or seven years before; the fracture was in the upper third of the bone, and had united previously with a very considerable angle, salient externally. Perhaps under these circumstances yielding is more to be dreaded in children; and we shall hereafter be confirmed in this idea by some facts concerning artificial fracture. I would, however, call to mind here the two children cured of fractures of the femur, in whom the fractures were repeated at different parts of the bones, (see page 31;) in fact the consolidation was regularly accomplished, but the subjects were rachitic.

On the whole, these facts should show how carefully convalescence from fractures is to be watched, even when the callus is ossified and apparently solid, and especially if union has occurred at an angle or with overlapping. The prognosis of secondary fractures is, moreover, not very serious; Delamotte has observed that they are neither so troublesome nor so tedious to cure as the primary; a fact which he explains by the spongy nature of the fractured callus. They are to be treated precisely as if primary. Thus for a bending of the callus which occurred in a young man of nineteen, which might very well be likened to an incomplete fracture of a child's bone, Oesterlen had steady, gentle pressure made with the hand over the salient angle, for several hours, and succeeded in bringing the bone to its right direction. M. Guillon preferred making gentler pressure for his patient, by means of an apparatus to be hereafter described. In case of complete rupture, reduction should be performed as usual, unless the previous deformity of the callus will not permit us to give the fragments their normal direction, obliging us to make use of special means. Then, moreover, the rupture is a fortunate occurrence for the patient, since it enables us to correct the angular deformity or overlapping; such was the case in several of the instances whose history is given by Oesterlen; nature performing an operation sometimes judged necessary by the surgeon, and one which will presently engage our attention.

§ XVI.—*Of Deformed Callus, and its Treatment.*

This is one of those difficult subjects on which surgeons are greatly at variance, that practice which some consider rational being formally disapproved of by others. Those deformities of the callus which may require treatment are of three kinds, clearly set forth by Celsus: (1) the fragments are joined at an angle or with overlapping, whence arises notable shortening and disfigurement; (2) two bones are fused together, as in the forearm; (3) the sharp point of a fragment, buried in the soft parts, keeps up a continual irritation in them.

In all these cases, according to Celsus, we must repeat the fracture, and put the fragments in better position. For this purpose, after using fomentations with hot water, and frictions with oil, he caused the limb to be extended, breaking up the callus, if it was yet tender enough, with his hands; if this manœuvre failed, he contented himself with compressing the projection of the callus by means of a wide splint (*regula*) wrapped in cloth, so as gradually to bring the fragments into place.

Galen likewise advises the reproduction of the fracture when it is still recent.* Paulus Ægineta goes further. He not only attacks the newly-formed callus, *which has not yet taken root*, but when it is entirely solid like stone, he would cut through the skin, and then divide it with cutting forceps. He seems, in extolling this plan, to find fault with another which consisted in breaking up the callus without any previous incision; so that at that period there would seem to have been known three principal methods of treatment: the correction of the callus before it became solid; its rupture, and its section, after it had ossified. A fourth, and much more recent method, is resection.

First Method; Correction of the Callus before Consolidation.—This method comprises two modifications, according as the reduction is made at one effort, by means of extension and vigorous coaptation, or more slowly by means of compression.

The sudden reduction is not much more than an application of the precept of Hippocrates, to remove the apparatus for the purpose of ascertaining or correcting the coaptation, after about two-thirds of the time necessary for consolidation had elapsed. This is the usual rule; but what has been said concerning the hindrances of consolidation may show that one may have reduction to perform even after several months; of which I have mentioned instances. Now if we read over carefully most of the observations of so-called vices of the callus corrected by extension and pressure with the hands, it will be seen that they come under one or the other of these two categories.

* Galen, *Ars medicinalis*, cap. xciii.

Dupuytren's *Leçons de clinique* contain ten cases of this kind of reduction: one is a fracture of the metacarpus, twenty days old; seven are fractures of the lower end of the radius, twenty to thirty-five days old; one a fracture of the tibia of three months and a half; and lastly there is one fracture at the middle of the forearm, of four months' standing; but these two last were not consolidated. The cases collected by Oesterlen afford perhaps still more instruction. Two were fractures of the leg, of forty-three and of eighty-four days' standing, in adults; these evidently were not consolidated. But in the six others, which were all fractures of the femur, of four, five, seven, and nine weeks' standing, most generally the attempts at reduction elicited an unequivocal crepitation, showing ossification to be at least quite advanced; it is remarkable that the subjects were all children, the youngest four and the oldest twelve and fourteen years old.* We have already noticed the greater frequency of accidental refractures in early life. It might be said that in children the callus, although more ready to ossify, is at the same time more easily broken, either because it shares the softness of the entire bony system, or because its less volume causes it to yield to slighter force. Three of the fractures of the radius reduced by Dupuytren after twenty-nine, thirty, and thirty-two days, were in children of ten to fifteen years old. M. A. Thierry says that he has often seen his father break with his hands the deformed callus in children, at the end of ten, twenty, or thirty days. He adds, however, that in all these cases the fractured limbs still retained some degree of mobility.†

The operative procedure is nearly always the same. If extension with the hands of assistants does not suffice, we resort to loops. Delamotte, in a case of fractured femur of nine weeks' standing, required only two assistants, using loops. Rapp, in a case quoted by Oesterlen, had extension made by four men; Dupuytren himself once thought proper to make counter-extension with a loop attached to a fixed point, and extension with another loop. Guy de Chauliac saw extension successfully made with weights; Fabricius of Acquapendente obtained a favorable result in a fracture of the leg, with a machine like the bench of Hippocrates, in which extension was made with a windlass. I think that pulleys give us at the same time greater safety and greater force, and would call to mind that they were successfully employed by Derrecagaix in a nearly analogous case, (see page 247.) While traction is made, the surgeon should press with both thumbs so as to efface the salient angle, or, if necessary, to break the callus; if this pressure is insufficient, an assistant should be called in. Guy de Chauliac recommends the employment of the knee; M. A. Thierry relates that his grandfather used his knee and

* Oesterlen, *op. cit.*, obs. 1 to 8.

† A. Thierry, *Du redressement des os fracturés; Expérience*, Nov. 4, 1841.

his hands at once, in renewing a six-months' old fracture of the femur, which, however, was not entirely consolidated. Lastly, we must not expect always to complete reduction on the first trial; if we do not, we should either repeat our efforts after a few days, submit the limb to permanent extension gradually increased, or resort to compression.

Compression may be made with splints merely, or with more complicated apparatus. The splints may be applied in three ways; sometimes the principal one acts directly on the projection of the fragments, as advised by Celsus; thus in a child four years old, with a fracture of the femur at the seventieth day, the convexity being anterior, Dupuytren first had the limb extended, and then put a splint on the front of the thigh, so as to compress without wounding the salient portion. Sometimes the splint is firmly fastened to the upper fragment, so as below to be widely separated from the lower one, which we then attempt to press toward it by bandages; in this way Dupuytren, having to treat a fracture of the leg twenty-nine days old, with an angle internally and the foot carried strongly outward, applied a strong inside splint, bringing the foot over to it by means of turns of a roller gradually tightened. Lastly, the splint may be placed on the other side from the angle; a pad being then laid over the projection, a cravat or band is made to surround both pad and splint, tending thus to bring them together. Dupuytren gives us an instance of this also; a man aged 44 had had for fifty-nine days an oblique fracture of the tibia with an anterior projection; there was placed under the limb a large cushion so arranged that its thinnest part corresponded to the ham and the thickest to the heel; a splint was put on over this cushion, and a small pad over the angle in front, and then the whole was bound together with a roller, so as at once to push the upper fragment backward and the lower one forward. This apparatus was kept on for twenty-eight days, at the end of which time the limb had regained its natural conformation. Desgranges of Lyons obtained, by a similar plan, a very satisfactory improvement in a fracture of the leg which had united with a marked angle externally, and which, it is curious, was of more than four months' standing.

I have given these cases as examples of the method pursued; but, in the leg especially, I am amazed that none of these accounts make any mention of pain, excoriation, or sloughing, especially when, as in some of Dupuytren's patients, compression has been kept up twenty-eight and forty days. Practitioners must not expect to find it always so harmless; and I shall speak, in connection with oblique fractures of the leg, of the apparatus which I have had to employ, not indeed to correct the improper direction of old fractures, but merely to keep recent ones in the right position.

Simple splints are, moreover, too liable to slip from side to side, and simple bandages too apt to become relaxed. Fabricius of Acqua-

pendente was the first, as far as I know, who used a special apparatus in such cases. A young servant-man had an old fracture of the leg united at an angle, so that the foot was everted. Rupture of the callus was at first thought necessary; but the father objecting to this, Fabricius attempted bringing it gradually into position by means of *certain instruments and plates of iron*, which he has unfortunately omitted to describe. He was successful; but he carefully adds that such a result could not have been attained in an adult.

Fabricius Hildanus had an outward curvature of the femur to treat in a child of eight years, the fracture dating back only eighteen days. He had a trough made of wrought-iron, to embrace the thigh externally, especially opposite the seat of fracture; it reached from a little above the trochanter down as far as the ham. This trough was carefully padded with fustian; two bands of the same, fastened above and below the knee, held it firmly to the lower fragment of the femur; it was now of course widely separated from the upper fragment, and a band, likewise of fustian, was buckled around the pelvis in order to bring them together. By tightening up this latter band two or three times daily, the projection of the fragments was entirely corrected in three or four days. I have used a similar trough, but made of wood, fastened with leather straps, and the parts guarded with wadding and compresses, to bring into place the two fragments in the refracture of the femur already mentioned.

Lastly, still more powerful means have sometimes been employed. In 1789, Desgranges of Lyons had to treat a fractured thigh in a boy of twelve; the patient was very intractable, constantly deranging his splints, and at the end of two months and a half the fragments presented a considerable angle outwardly. Desgranges had a machine made analogous to the compressor of Scultetus for the radial artery, consisting of three iron splints connected above and below by circular bands of the same metal, thus solidly embracing the limb. One of these splints was perforated so that a screw could be worked in it, carrying a pad to press on the projecting angle, on the principle of the tourniquet. This pressure was increased daily, while steady extension was kept up. At the end of three weeks, the improvement was so great that extension alone was sufficient; three weeks later, the consolidation was complete and regular, and the child subsequently became a soldier.*

M. Guillon employed, in 1828, an analogous machine to correct accidental curvature in a fracture of the femur, the callus having bent after four months and a half. (See *ante*, page 264.) Continuous extension was effected by means of an apparatus with two splints; the outer splint, which was very thick, and fastened to the pelvis by a buckled girth, was traversed by the screw of a tourniquet, having

* Jacquemin, *op. cit.*, obs. 4; Sculteti, *Armam.*, tabul. xxi, fig. 4.

at its extremity an oval pad five inches long and four wide, hollowed to adapt it to the shape of the thigh. The compression was kept up for twenty-two days, after which extension alone was continued for twenty-four days; and on the sixtieth day after the bending of the callus, it had acquired its proper shape, and firmness enough for the patient to walk with crutches.

Again, in a young man of twenty-five, having a very much deformed fracture of the radius of forty-five days' standing, M. A. Thierry employed a hand-vice in bringing it into shape; pressing gradually for one hour upon the fragments, the limb being wrapped in flannel and cotton. The first attempt having failed, another was made three days afterwards, with complete success.

A question of importance in connection with this first method, is whether science has supplied any means of softening the callus, so that it may yield more readily. We have seen that Celsus recommended fomentations with hot water, and frictions with oil; others have extolled baths, douches, poultices, plasters of all kinds; and Desgranges employed, on one of his patients, the inunction of bear's-grease. Neither theory nor experience will warrant our ascribing any efficacy to such means; poultices or baths may dissipate any remaining engorgement around the callus, but cannot act directly upon this. In none of the cases reported by Oesterlen was any preparatory treatment resorted to; Dupuytren gave it no more consideration; and in one case only, where he wished to make very powerful extension, the patient being young and vigorous, he ordered a bleeding and a bath, as he would have done in a case of luxation. Therefore, the correction of the callus being decided upon, it should be done as soon as possible; and except in cases where there exists inflammation or engorgement, the so-called preparatory treatment only makes us lose precious time.

Second Method; Rupture of the Callus.—This method also is variously modified, according as we operate by percussion, by sudden and forcible, or by gradual and moderate pressure.

Percussion would seem to have been in use in Asia among the cotemporaries of Rhazes; but he does not say how it was performed, nor does he mention it except with disapprobation. Fabricius of Acquapendente speaks of a process which consisted in breaking the bone with a hammer, the part being so wrapped up in cloths or sponges as to break the force of the blows. But, like Rhazes, he condemns the plan, because of the danger of breaking the bone at some other point than at the callus.

Rude and forcible pressure was made by placing a stick across the limb, and then bearing down strongly on its two ends. Fabricius of Acquapendente, who first mentions this, rejects it for the double reason that it may break the bone at some other point, and that it may cause too much contusion of the soft parts. Oesterlen tried

something similar, but as an experiment merely, upon the humerus of an old woman whose death occurred eight weeks after her fracture. The bone being placed transversely over two sticks, the experimenter bore strongly upon the middle of the callus with another stick which he held in both hands; the callus broke under this force; but we should consider that it was of only recent date, and also that the soft parts had been removed. Pressure with the thumbs and knee would certainly be safer, but it is doubtful whether it would be sufficient to break a well-consolidated callus.

Moderate and graduated pressure requires the employment of a screw acting directly on the bone, like a tourniquet. Purmann would seem to have been the first to recommend a screw; but his advice and his machine were both forgotten, when in 1782 Bosch, studying surgery in Augsburg, found among his master's apparatus an old iron affair which he thought must have been used to break up callus; as it was highly complicated, he set to work to simplify it, and in 1783 he used it successfully on a fracture of the femur, united at an angle, and dating back twenty-eight weeks. A second attempt, as fortunate, was made on a fracture of the leg the date of which is not given, and subsequently several more; but nothing had been published concerning these operations, until in 1811 Oesterlen had occasion to see Bosch use his apparatus under the following circumstances.

A young man of twenty-six had had his right femur broken at about the middle, by a fall from a carriage, and had been so carelessly treated that the fragments made an angle forward and outward like that of the knee when semiflexed, and the limb was shortened more than four inches. The fracture was sixteen weeks old. Bosch made him lie on a table, had counter-extension made by two assistants with a cloth around the perineum, and extension by two others, and applied his apparatus; this resembled very much a bookbinder's press, two boards being brought together by means of two screws placed toward the ends. The thigh was put into the press, directly across it; then in order to moderate the pressure, a very wide roller was placed on the projection of the callus, the upper board pressing on the upper side of this roller. Extension being now steadily made by the assistants, the operator rapidly turned both screws at once, until the patient complained of pain at the seat of fracture. Then the assistants were directed to increase the extension, while the screws were worked more slowly, though without stopping, till at last crepitation was distinctly heard, when the extension was taken off and the machine removed. This however was not all; Bosch had the thigh raised by two assistants, at first gently, and afterwards forcibly, while he himself pressed with both hands on the angle of the fracture; crepitation was again heard; the patient complained of greater pain; and some mobility became apparent. In order to disengage the fragments, an assistant passed a cloth round on the

inner side of the fracture, and then pulled outward on the ends with all his strength; while the operator, placing his left hand on the inner side of the thigh, above the callus, and his right on the outside, below it, sought by thus pushing in opposite directions to complete the fracture; this at last occurred with renewed crepitation, and now the fragments, disengaged from one another, could be reduced. The operation lasted in all ten minutes; there was neither contusion nor ecchymosis; the pain, which seemed to be caused more by the extension than by the pressure, was much relieved. The subsequent course of the case was very simple; eleven weeks afterwards the patient began to go about; the shortening was only a little over two inches, or in other words, there were gained twenty-one lines in the length of the limb by the operation.

In 1817, Oesterlen assisted at an operation of the same kind for a fracture of the leg sixteen weeks old, which was still more completely successful; and he relates five other observations communicated to him by Bosch; viz.: a fracture of the humerus which had occurred at birth, of six weeks' date; a fracture of the leg, three months; a fracture of the arm, six months; and two fractures of the femur, of five to six months.*

Bosch afterwards improved his apparatus as follows: There were always in it two boards of beech-wood, fourteen inches long, five wide, and one and a half thick, joined by two screws, so that the distance between them could be altered at will; but the lower one was furnished with two longitudinal hair-pads, intended to keep the limb up, leaving between them an empty space into which the callus might sink; the other one had at about its middle a hair-pad about two and a half inches in diameter, intended to press directly on the callus. It should be added that the lower board had at each of its four angles a screw, to fasten it firmly to the operating table.

[Dr. Gurdon Buck, in a communication made in 1855 to the New York Academy of Medicine, related the history of six cases treated at the New York Hospital, in which old and badly-united fractures of the thigh were forcibly broken up, and the deformity corrected; in all these the result was favorable. (See *Transactions of New York Acad. of Med.*, vol. i, part iv.) One of these cases is a very remarkable one; it is that of a boy aged 5 years, who had a fracture of the left femur. The bone had been *three times* broken over again by a quack, to correct deformities of the callus; finally the boy came under regular treatment, and the operation was done for the *fourth time*, with a favorable result.

On the books of the New York Hospital are recorded two artificial refractures, one of which, in the left femur of a young man aged 19, lessened the shortening of the limb from four inches to one and three-

* Oesterlen, *op. cit.* obs. 9 to 17.

quarter inches; the other, in the left radius of a man aged 26, three inches above the wrist, was perfectly successful.

In February, 1851, I saw Dr. W. E. Horner perform, at the clinic of the University of Pennsylvania, a refracture of the leg of a young man. The original injury had taken place twelve weeks previously; the patient was etherised, and the limb put up in splints so as to afford a better purchase; the case did perfectly well.

In 1855 I myself refractured the left forearm of a boy aged 13, for a bending backward of both bones, consequent upon a fracture which had taken place three months before; simply grasping the forearm, which had just been again fractured below the angle, with both hands, and bearing it down over my knee, so as to efface the angle. The bones united without any deformity in six weeks.]

Third Method; Section of the Callus.—This method consists mainly in dividing the integuments so as to act more directly upon the callus. Paulus Ægineta, as has been stated, used cutting forceps, and Fabricius Hildanus speaks of a stupid surgeon of his day who proposed thus to divide a callus ten months old; but it was left for the nineteenth century to see the plan put into execution; yet I can only quote three such cases.

Gardeil, in a note to the *Book on Fractures* of Hippocrates, says that he had *had the bones of the forearm cut, in one of his nephews, at the original seat of fracture, two months after they had been set and bandaged in the supine position.* The callus had formed well, but the child was completely crippled in the right hand; he could neither write nor grasp firmly with it. The operation was perfectly successful.

I have related, in my *Médecine Opératoire*, the operation done by Wasserfuhr on a child of five years, for a fracture of the femur of only three weeks' date. The fragments formed a right angle upward and outward; Wasserfuhr made over this angle an incision comprising one-quarter of the circumference of the thigh, sawed partly through the callus and broke the rest of it, and succeeded perfectly.

But a still better instance was furnished some years since by the London surgeons. The patient had had the tibia broken by a ball, and united angularly with so much shortening, that several surgeons had advised amputation. Mr. Aston Key and Sir Astley Cooper thought proper to attempt the section of the callus. An incision four inches long was made over it, the tibia was separated from the surrounding soft parts, and divided partly with a chain-saw and partly with an ordinary saw. This section made, it was found unnecessary to cut the fibula in order to effect reduction. However, to keep the limb in place, permanent pressure was required, and made by two tourniquets so arranged as to push the thigh and foot outward. The symptoms were very slight; at the end of four months

the wound had cicatrised and the callus was firm, the shortening of the leg being but trifling.*

Fourth Method; Resection of the Callus.—The first known operation of this kind dates back only to 1815; Oesterlen communicated it to Lemercier. It concerned a fracture of the leg, of only forty days' standing, consolidated with great curvature; three lines of the lower and outer end of the upper fragment were sawn off, and about as much of the upper and inner end of the lower one; three weeks afterwards there was every reason to hope for a perfect cure.

A second attempt was made by Riecke in 1826. A young man aged 20, having been treated for fracture at the middle of the femur with Sauter's suspensory apparatus, was dismissed at the end of eight weeks with so much curvature outward, that the limb was shortened eleven inches; the upper fragment projected strongly against the skin, and the lower joined it at an angle, six or eight inches above the projecting point. Riecke made a long incision, from near the trochanter down to the external condyle, detached the muscles from the bone, divided one-half the callus with the saw, completed the section with a hammer and chisel, and lastly resected some three lines of the wounded end of the upper fragment. There ensued fearful suppuration, and numerous necrosed splinters came away; and it was not till the eighth week that the patient was out of danger. Eight months were required for complete consolidation.†

[In 1850 I saw an operation performed by Dr. W. E. Horner, at the clinic of the University of Pennsylvania, upon a man who had sustained a fracture of the femur eighteen months before; the limb was shortened four inches. Dr. H. made an incision at the outer and back part of the thigh, sawed off the ends of both fragments, (the fracture had been a very oblique one,) and then made extension by means of pulleys until the shortening was reduced to half an inch. Gangrene and phlebitis carried off the patient in four days.

It seems to me that the result of this case may be clearly traced to the great and sudden extension to which the limb was subjected.]

So far, the resection is pure and simple, sometimes of one, sometimes of both fragments, the object being to freshen up, as it were, their extremities, and favor coaptation; and under this head should be placed also two operations undertaken by Portal in 1837 and 1840, the first for an angular callus of the leg, thirty-three days old, the second for an angular callus of the femur, forty days old. Less than two months sufficed for the cure in each of these cases.‡

But there is another method, devised in 1834 by M. Clémot, of Rochefort, which consists in cutting away with the saw a wedge-shaped portion of the callus. A child forty days old had an angular

* *Gazette Médicale*, 1839, p. 366.
† Oesterlen, *op. cit.*, pp. 124 and 126.
‡ *Gazette Médicale*, 1841, p. 601.

curvature of the femur, probably occasioned by the manipulations of the accoucheur at the time of its birth. After in vain employing for several months an apparatus for making extension, M. Clémot made an incision five centimètres long over the callus, separated the muscles from the outer three-quarters of the bone, and with a narrow saw removed a wedge comprising two-thirds of the thickness of the callus; the remainder yielded to bending force, and the child was cured in seventy days. A similar operation was done for a similar affection in a man of twenty-seven, on the twenty-fourth day of a fracture at the middle of the femur.*

M. Velpeau quotes another case operated on by Warren, for a fracture of the tibia, and likewise attended with success; he does not mention the date of the fracture.

[This operation has been not unfrequently performed in the United States, though the published reports are rare. A case occurred to Dr. Pancoast, of Philadelphia, about two years ago, quite illustrative of its value. It was that of a girl of twelve, who had broken the right leg about two inches from the knee, and recovered with the knee bent at a right angle, and the fracture firmly united at a somewhat wider angle, salient posteriorly. The child's constitution was scrofulous. Her parents said they would prefer amputation to the leg as it was; and Dr. Pancoast determined on resection. Ether was given, and the inner hamstring muscle divided subcutaneously, so as to allow of partial straightening of the knee. Then an incision was made over the deformity, and a wedge-shaped piece was taken out from the tibia, leaving a small portion anteriorly to be ruptured by straightening the leg at the seat of fracture. This was now done, and the case treated like an ordinary compound fracture. The result was perfectly satisfactory, the child recovering with a very useful limb.]

To form a serious judgment between these different methods, we should examine separately the three kinds of deformities of the callus to which their application may become necessary; and the first of these both in frequency and in gravity is certainly angular deformity, or considerable overlapping.

Now on comparing, with regard to this, the four methods and the cases pertaining to each, we are first of all struck with one thing, viz., that with the exception of Aston Key's operation there is not a single one of the sections or resections of the callus which would be justifiable. Fractures of only three weeks, a month, forty days, at most eighty days' standing! Fractures united at an angle, the least firm of all forms of union; and lastly, in the majority of cases, in children, in whom we have seen the facility of correcting it! Cer-

* Clémot, *Mém. sur la Résection du Fémur pour un cal vicieux; Acad. de Médecine*, May 24, 1836.

tainly we must be indulgent toward the authors of such operations, since unhappily the silence of modern classical treatises would leave them convinced of the impotence of art; but at the present day, with the facts now known and established, considering the successes obtained by means of energetic extension and by machines for breaking the callus, even in older fractures than those for which section or resection have been tried; if, moreover, we think of the danger attending these bloody operations, the most moderate conclusion must be that we should never resort to them without having first tried the other two methods.

I would go further; before attempting to rupture the callus by a machine, the various other plans for adjustment should be exhausted. The time that has elapsed since the fracture is not an objection, at least in all cases; we have seen, moreover, to what delays and hindrances consolidation is subject; and it is to be noted that the greater the angle formed by the fragments, the less solid is the callus. Besides, between the tourniquet of Desgranges, the vice of M. Thierry, and the machine of Bosch, there is but little difference, and that lies more in their use than in their construction. Bosch himself, notwithstanding the power of his machine, has hardly gone beyond the limits fixed by Guy de Chauliac and the other advocates of adjustment. They would let the callus alone if it were more than six months old; once only did Bosch attempt a fracture somewhat later, but even that was but six months and a half.

Thus then, we try first adjustment, and afterwards rupture. There have however been raised, against this latter method particularly, two objections which it is important to examine; first, the danger of breaking the bone at some other point; and secondly, in some cases, the fear lest the rounded ends of the fragments should not be capable of uniting.

The first of these objections is nearly valueless when we make use only of extension or of gradual compression; and when a resort to rupture becomes necessary, I think that by observing the precautions given by Bosch we are equally certain as to the result. In fact, we never meddle with the callus unless it is very much deformed; and it suffices to look over the accompanying engravings to be convinced, that however little the fragments may deviate from the normal direction, the callus is always formed of spongy tissue, and is therefore easier to break than the diaphysis, unless there be some special disease of the bone. Lastly, besides our observations on the living, our experiments on the dead body would make us certain on this point. I have already (page 262) quoted M. Jacquemin's experiments on recent fractures; let us examine some others on fractures of much older date.

A three-year-old bull had had the cannon-bone fractured, and reunited at a considerable angle. Six months and a half afterwards,

he was killed; Bosch and Oesterlen tried breaking the callus by means of a jack, and the rupture took place without splinters, and without any injury to the original fragments.

A two-year-old roebuck had had the right haunch-bone fractured, and reunited at an angle. *Five months and a half* after the fracture the animal was killed, and Oesterlen tried breaking the callus with Bosch's improved machine. Here also the rupture occurred across the callus.*

The other objection was put forward by Sanson; it does not concern callus which is merely angular, but only cases of overlapping, with or without angular deviation. Here, said Sanson, the fragments will not unite, because their extremities will be cicatrised. M. Laugier has replied, (1) that it was not union which was deficient in the cases of rupture of malformed callus; (2) that even supposing the ends of the fragments not to be in a favorable state for reunion, they would unite in great part by the new surfaces of the osseous or cartilaginous callus.

On the whole, these objections seem to be more plausible than real, and are not such as would deter a surgeon from the operation, where the existing indications were sufficient. But it is these indications which must be seriously discussed; for although so far we have seen only successes, we must not consider either rupture or adjustment always such safe operations. Among the Arabians, Ali Rodoham saw an old man of seventy, who, having placed himself in the hands of a bone-setter, died under the operation.† Morgagni saw also a physician who, having caused a still very recent fracture of his leg to be broken up again, was attacked with the worst symptoms, and finally succumbed; and M. Laugier relates the case of a fracture of the femur united with an inch and a half shortening, which at the end of nine weeks was subjected to forcible extension with pulleys; the callus was broken up, but the patient died in an hour and a half afterwards.‡

Thus, like all other operations, these have their dangers, which must be weighed against their possible utility. Assuredly, before two-thirds of the time necessary for consolidation has elapsed, or while there is still mobility between the fragments, we need not hesitate to again perform reduction, provided we can certainly keep it up. When the callus seems solid, even within the first month, there must be

* Oesterlen, *op. cit.*, obs. 18 and 29.

† On the authority of Guy de Chauliac and Joubert, this case is universally ascribed to Haly Abbas. Now there is not in all the extensive treatise of Haly Abbas a single word relating to it; and moreover Guy de Chauliac cites the third book of the *Techne*, which never belonged to Haly Abbas. Ali Rodoham was the author of a commentary on the *Techne* or *Ars* of Galen; and it was in fact there that he found this case mentioned.

‡ Morgagni, *De sedibus et causis morb.*, Epist. LVI, § xxviii; Laugier, *Des cals difformes et des opérations qu'ils réclament, Thèse de Concours*, 1841, p. 62.

great deformity, and great interference with the functions of the limb, to justify us in attempting either adjustment or rupture. But when these two conditions exist, making the limb rather a burden to the patient than an assistance and support, it is, in my opinion, never so late that art cannot or ought not to afford the necessary aid to the sufferer; and after an ineffectual trial of rupture, I should no longer hesitate to perform either section or resection.

So much, then, for angular callus or great overlapping. The second variety of malformed callus comprises the fusing together of two parallel bones, such as those of the leg or of the forearm. M. Laugier has made an interesting observation on this point; it is that this fusion of the two bones does not always take place from one fracture to another, but sometimes between a fracture of one of the bones and a healthy portion of the shaft of the other. An apparently essential condition is that both bones should be broken, but not at corresponding points. An example of this kind of fusion of the tibia with the fibula may be seen in *Figs.* 89 and 90; it is less common in the forearm than in the leg, though it is well to be aware of its possibility.

As one might suppose, in the leg such a condition would be without inconvenience, and even sometimes impossible to recognise; but in the forearm it is a different affair, involving the absolute loss of the power of pronation and supination. Thus, since the time of Celsus, it has been considered a legitimate reason for forcible adjustment; but it must be admitted that this is a plan more easily advised than put in practice. I have been able to find but one case of this kind in which an operation was attempted; it is the one mentioned by Gardeil, in which it would seem that section of the callus was performed. I shrink from laying down any law on this point, leaving the question to be decided by each surgeon according to his own judgment.

There remains only the third form,—when a fragment projecting beneath the skin or among the tissues becomes a source of continual pain and irritation. When the callus is soft, to attempt to restore it to its place is a matter as simple as it is natural; but if the callus is hard, and does not otherwise hinder the functions of the limb, it would be absurd to try to destroy it in any way; the only indication is to resect the projecting point.

It is stated that Ignatius Loyola, having had his thigh broken during the siege of Pampeluna, and having recovered with deformity, caused the callus to be broken up; but he was again so carelessly treated that one of the fragments formed a prominence above the knee; and the patient, it is said, had this end resected. This was the first instance of resection of a bony fragment in a fracture of long standing.

A resection of this kind was performed by M. Velpeau upon a

woman, who, in consequence of a comminuted fracture in the lower fourth of the humerus, had one of the fragments forming a long sharp ridge under the skin, above the epicondyle. As this ridge gave her pain, and interfered with the movements of the forearm, she desired to get rid of it. An incision two inches in length along the outer part of the humerus laid bare the bony prominence, which was removed with cutting forceps. The wound healed by the first intention.

Frequently, after oblique fractures of the leg treated by the ordinary means, there remains a sharp point of one of the fragments beneath the skin. M. Velpeau mentions the case of Meyranx, who had to the day of his death such a projection, causing ulceration and almost constant pain. Resection would have been the only remedy; and the operation is so simple, and so free from danger, that we can but wonder, with M. Velpeau, that science possesses so few examples of it.*

[It would seem as if the rarity of this operation might be easily accounted for by the rarity of the cases demanding it; and this again by the fact that almost always Nature herself takes charge of the case, the sharp points becoming softened, rounded off, and absorbed. Such a process may more readily occur when the offending portions of bone still retain their vitality, so that the work of their removal is not yet beyond the province of absorption; this condition once lost, the surrounding tissues can keep no terms with the disturber, and the difficulty can only be allayed by its ejection, spontaneous or artificial.]

Before closing this section, I may mention that I have proposed, in cases where section of the malformed callus seems indispensable, to introduce by a narrow wound a steel chisel, and to drive this by a leaden mallet, so as to break the callus without admitting the atmosphere to it; even if this latter object were not attained, the rupture would be made with less disturbance, and the conditions of a recent fracture more closely approached, than by using a saw through a large incision.

§ XVII.—*Of some Diseases of the Callus.*

It is not my purpose to revert here to the softening of the callus from scurvy, erysipelas, etc., which was mentioned in connection with false joint; but we may properly study by themselves certain affections peculiar to the callus itself, either before or after its complete consolidation; a subject by no means unimportant, and far too much neglected by surgeons. I shall dwell successively upon *pain* in the callus, *exuberance* of it, and the *fleshy granulations* to which it may give origin.

* Velpeau, *Méd. Opératoire*, second ed., tome ii, p. 599.

(1.) *Of Persistent Pain in the Callus.*—There are a great many fractures, especially among such as are united by a deformed or voluminous callus, which give rise to pains, sometimes acute, sometimes dull, recurring at every change in the weather. Théden broke his right humerus three inches above the elbow; the fracture, although attended with great suffering, was consolidated in seven weeks. But during the whole of the ensuing year, the least change of weather was announced to him twenty-four hours beforehand by severe pains both within and around the callus. He applied his compressory bandage, with relief to the outward pains; in time the internal pains became likewise more endurable; but at the end of ten years he still felt them occasionally.

I have known these pains to persist after several years in a young person of twenty, who had sustained a fracture of the clavicle. I have likewise observed them in adults and old people, to whom, according to their expression, they served as a sort of barometer.

Now what is their nature? Théden ascribes them to the pressure exerted on surrounding parts by the material thrown out for the callus, and by the hindrance it involves to the circulation of the fluids in the periosteum and marrow. "Je sentois parfaitement," he says, "l'impulsion des liqueurs sur le cal; je pouvois distinguer celle qui se faisoit interieurement."* This view is too hypothetical to demand attention; all that we can say on this head is that it is with the callus as with cicatrices in the soft parts, which also give rise from time to time to barometric pains; and just as cicatrices which have been the slowest to form are generally the most painful, so also vitiated callus is more troublesome than the ordinary.

We must not confound these pains recurring in an old and firm callus with such as depend on some defect or hindrance of consolidation. I have seen numerous examples of such; the simplest and surest remedy is then to keep the limb in an apparatus as long as may be necessary. A young girl made a misstep, and was thought to have sustained a simple sprain; at the end of twenty-five days, the ankle-joint being supple and painless, she was allowed to walk about. But soon severe pains, developed at the lower part of the leg, absolutely prevented her from putting her foot to the ground. It was not known what could have caused them; the circumstances of the accident, and the localisation of the pains at one point in the fibula, led me to diagnose a fracture of this bone; and an albuminated apparatus, worn for three weeks, produced a complete cure.

In this case, the fracture had not been recognised; at other times the fracture is clearly made out, but subjected to some hindrance, revealed before long by the pains. The treatment is the same, and

* Théden, *Progrès ult. de la Chirurgie*, translated from German into French, Paris, 1777, pp. 42 and 139.

is almost certain of success; if, however, the pains persist, they may be dissipated by a blister at the point of fracture. A patient affected with a fracture at the upper part of the femur, treated at first by permanent extension, which he could not endure, and afterwards by ordinary splints, had tried to go about at the end of twenty-four days. The limb appeared firm; pains, however, were soon felt at the level of the callus. The application of another apparatus not having availed to relieve these, I used three flying blisters in succession, with the desired effect.

(2.) *Of Exuberance of the Callus.*—Certain fractures, principally those of the upper fourth of the femur, below the trochanters, are surrounded by callus to such an amount as by its weight, its volume, and its projecting points, to interfere notably with the functions of the limb. I have represented such a case in *Fig.* 72; but I have seen them even more voluminous.

This exuberance of the callus strongly attracted the attention of the ancients. "When this occurs," says Celsus, "we must apply to the limb gentle and prolonged frictions with oil, with salt, and with nitre; use copious fomentations with salt water; apply a resolvent poultice; increase the pressure of the bandage; give a vegetable diet; administer emetics; all which means, by emaciating the soft parts, will likewise attenuate the callus. We may also prescribe a cataplasm of mustard and figs for the sound limb, so as to raise the epidermis, and attract thither the humors."

Paulus Ægineta is bolder; if local astringents, and compression with leaden plates are not sufficient, he advises laying the callus bare, rasping it, and removing all the projecting portion; if necessary, even applying the trephine.

We find these precepts copied by the Arabians, and even by later writers; I know, however, of no case in which they have been acted upon; and if the callus be hurtful only by its volume, it would be certainly better, after having tried the gentle means proposed by Celsus, and perhaps douches and sea-bathing, to let the patient live with this annoyance than to subject him to an operation the doubtful benefit of which would not compensate for its danger.

But sometimes there is joined to this hypertrophy of the callus another morbid condition: intense pains in the callus itself, with bad effects upon the entire limb. M. Guyot has given a remarkable instance of this, which is in every way worth mentioning here.*

M. Turgot had sustained a fracture of the right femur in its upper third, by a fall from his horse. Dupuytren, who was called, applied at first an eighteen-tailed bandage, with direct extension; at about the fiftieth day he substituted for this the double inclined plane. This

* Guyot, *Des accidents consécutifs aux fractures; Archiv. de Médecine*, Feb., 1836.

change of posture bent one fragment upon the other, with great swelling and intolerable pain; the callus was slowly developed, and deformed. However, the patient walked about, when, to get rid of some remaining stiffness in the knee, he resorted to the waters of Néris, [mineral springs.] Under the influence of these the callus swelled, and became the seat of severe pains; the whole member became œdematous and of a deep violaceous tint. The limb was now useless as a support; the slightest shock on the point of the foot was acutely felt in the callus and whole upper portion of the thigh; and the patient could not rest his weight on the deformed callus without a sensation of fatigue increasing in a few minutes to actual pain. All the means employed failed; it was only by the third year that the pain, swelling, and violaceous tint of the skin were in a measure dissipated by sea-bathing, but the other symptoms remained; and the patient could only walk with two crutches. Damp or stormy weather increased his uneasiness, even to an inflammatory condition, as shown by the swelling, pain, heat, spasmodic contractions of the muscles, and often fever. These accessions lasted from six to nine days.

On examination, M. Guyot found the fragments overlapping, and forming a slight angle forward and outward; but especially surrounded by an enormous callus, with great engorgement of the surrounding soft parts. Thinking at first that the bone was wanting in solidity, he attempted to supply this by means of a thigh-piece, which gave relief for a time, but then became insupportable. Gradual extension by means of Boyer's mechanical splint seemed more effectual; in eight days the limb resumed its natural color and size; but on the thirtieth day, a movement of the patient's having reproduced the pain, this remedy likewise was considered hopeless. Lastly, recourse was had to a large blister, which, having a good effect, was followed after some days by a second, and this by a third; and in twelve days after the first one was put on, the patient was able to get up, and to rest his weight on the diseased limb. In order to perfect the cure, it was thought fit to apply, on the outer and posterior part of the thigh, at the level of the callus, a cautery large enough to admit eight or ten peas; and some months later the limb had entirely recovered its color, form and functions.

M. Guyot reports two other cases, analogous to this, but not so complete; they also were fractures at the upper part of the femur; in the second one, the pain was twice relieved by blistering, and twice reappeared, when the cautery finally put an end to it.

This affection of the callus has exactly the character of a state of chronic inflammation, occupying its substance as well as involving the periosteum and the neighboring fibrous tissues. In the cases observed by M. Guyot, there were some symptoms of gout or rheumatism, which may perhaps have influenced the persistence of the pains.

In some cases the volume of the callus depends on its having a central cavity, ossification occurring only at the circumference; Professor Weinhold, of Halle, suddenly entered a cavity of this kind in endeavoring to transfix the callus with a seton. This attempt ought the rather to be known, since it was followed by success.

A young man of eighteen, who had sustained a fracture at the middle of the femur, undertook to walk and to resume his occupation at the end of the fourth week. Six weeks afterwards, the limb was shortened by two inches, and the callus was enormously increased in volume; its circumference was eighteen inches and a half; the surrounding cellular tissue was engorged, and at different points there were abscesses formed, tending to become fistulous. Weinhold at first tried extension with pulleys, but the callus did not yield. He then conceived the idea of passing a seton through, in order to provoke suppuration and softening of the callus, with a view of again trying extension. Therefore, with a trepanning-needle* mounted on a brace, he pierced the soft parts at about an inch from the femoral artery, and gently perforated the outer layers of the callus; after which the instrument suddenly went about four inches deep before reaching the opposite wall; the callus being perforated anew at this point, the needle was pushed through the muscles and skin, and the seton introduced. The part was for three days dressed with cold poultices; on the fourth the seton was smeared with balsam of Arceus [something similar to our *Elemi ointment*,] and then pulled upon twice daily. By the fifth week a copious suppuration, flowing at each opening made by the seton, resolved the engorgement of the cellular tissue; then the fistulæ closed up; the callus in its turn inflamed and suppurated; at least so Weinhold thought, from feeling it yield under the pressure of his finger. He now resorted again to extension, and with such success that by the tenth week the limb was only shortened two lines. For greater security, the seton was still retained for fifteen days; and some weeks later, the wounds were cicatrised, the thigh was of its normal size; the patient could walk without crutches, and in the end he recovered nearly his former strength.†

(3.) *Of Fungous Growths from the Surface of the Callus.*—This complication naturally implies a communication externally of the fracture or of the tumor formed by the callus; the only instance of it which I can cite was the result of gunshot fracture; and it will be noticed that the callus was in the same condition as in Weinhold's patient, hollowed out internally, ossified at its circumference.

A soldier received a shot which broke his left thigh just below the

* ["*Aiguille à trépan.*" The precise form of this instrument is not stated; it may be that the author means the perforator deprived of the crown of the trepan.]

† *Archiv. Gén. de Médecine*, 1828, tome xvii, p. 446.

great trochanter. The necessary incisions were made for the extraction of the ball and of the other foreign bodies; but in spite of the treatment adopted,—probably from scurvy, with which the man was attacked, the fracture was unconsolidated at the end of six months. Granulations had sprung up in the wound, and from them there was lost at each dressing quite a quantity of blood; more than five months elapsed without any great improvement. A new surgeon now taking charge of the patient, discovered several sinuses formed on the anterior and inner part of the thigh, and opened them; he also tried to destroy the fungus with weak caustics; all this failing, he determined to saw off more than a finger's-breadth of the lower fragment, which by its overlapping irritated the neighboring parts and caused very severe pain. He did not succeed, as he had hoped, in thus obtaining coaptation; but all the symptoms were moderated, exfoliation ensued, healthy suppuration was set up; and in two months' time the callus acquired great firmness. Nevertheless, the wounds would not cicatrise; and the patient, exhausted at length by pain and suppuration, died after five years and nine months of suffering.

At the autopsy, it was found that all the fistulæ opened into a large cavity in the middle of the callus, which was very large and irregular; this cavity was lined by a kind of membranous pocket, pretty thick, of soft consistence and whitish color, and which in spite of the presence of the pus, had defended the callus from caries; while the sinuses, extending widely, had exposed and made carious the great trochanter and the coxo-femoral articulation.*

§ XVIII.—*Of Cases Requiring Amputation.*

Some fractures are so serious, either from their original character or from their consequences, that amputation may become the patient's only chance of safety, or a desirable means of relief from insupportable infirmities. In the first case the operation may be either *primary* or *secondary;* in the second, it is always performed a good while after the occurrence of the fracture, and may be called *consecutive.*

(1.) *Of Cases Requiring Primary Amputation.*—I have no intention of treating this subject at any length, as it belongs quite as much to the study of amputations in general as to that of fractures; it will be sufficient for me briefly to sum up the principal indications. In general we are called on to amputate:

When, besides the fracture, there is almost complete division of the soft parts. We should however make an exception in some injuries by cutting instruments; not only have fingers been made to adhere after being cut off, but so also have nearly complete sections of the metacarpus, of the metatarsus, and even of the arm.

* *Mémoires de l'Acad. de Chirurgie,* tome iv, p. 625.

When the bones are so crushed as to make union appear impossible.

When, the fracture being simple, the soft parts are so mashed and bruised that gangrene seems inevitable.

When the great nervous and vascular trunks are both destroyed.

When there is fracture into a joint, with extensive opening into a large articulation. This rule seems to me to be absolute as regards the knee-joint, although some instances are given to the contrary; in the other articulations exceptional cases are quite frequent.

Lastly, *when the fracture is complicated with spontaneous emphysema, without any communication with the air-passages.*—I shall dwell particularly on this complication, since the classical treatises pass it over in silence, M. Velpeau alone making mention of it. He states in his *Médecine Opératoire*, that he has seen it in six patients; once in the arm, with recovery, and five times in the leg, with three deaths. More recently, the *Gazette des Hôpitaux* has published another case occurring in his wards, a fracture of the forearm with a wound and emphysema; in spite of all his efforts, gangrene came on and spread, and on the eleventh day the patient died.* In 1836, M. Martin de Bazas called attention to this subject, and published the two following cases.

A young man, aged 20, of good constitution, had his right hand caught between a wall and the end of a barrow he was rolling; there was contusion of the soft parts of the fore and middle fingers, the first phalanges of which were fractured. Some hours after the accident, the surgeon who was called found an emphysematous swelling extending up to the elbow. In spite of antiphlogistic treatment, there ensued very intense inflammation of the lymphatics, which from the wounded part spread gradually over the whole of the arm, the axilla, and the front of the thorax. An inflammatory œdema had superseded the emphysema, all trace of which was gone; the fever was intense; on the seventh day tetanic symptoms appeared, and the patient died on the night of the tenth day. The autopsy revealed a transverse fracture of the first phalanges of the fore and middle fingers, with contusion of the tissues, and laceration of the vessels and nerves; the entire subcutaneous tissue of the limb was gorged with a reddish serosity, without any sign of air or of pus; the deeper structures and the nervous trunks were sound.

Although death ensued, this was a case of benignant emphysema, since it did not occasion gangrene. This fearful consequence was present in the other case.

A mason, while tearing down the front of a wall, had his right foot completely crushed, and the tibia and fibula broken, with lacera-

* Velpeau, *Méd. Opérat.*, second edition, tome ii, p. 321; *Gazette des Hôpitaux*, 1844, p. 458.

tion of the soft parts and protusion of the muscles of the calf. The hemorrhage was stopped by means of a roller; but the patient having been six or seven hours afterwards carried to the hospital, an emphysema was remarked, commencing immediately above the knee, involving the whole thigh, and losing itself in the lumbo-abdominal cellular tissue. Amputation was proposed, but the patient refused to submit to it, and twelve or fifteen hours after the accident he was no more.*

M. Colson witnessed another instance of this in a fracture of the fibula, with luxation outward of the foot and protrusion of the tibia inward through the skin. Two emphysematous patches reached to the upper third of the leg; thirty-six hours afterwards gangrene commenced at the wound, and the patient submitted to the amputation of the limb, which at first he had refused; it was done on the eighth day. The gangrene had seemed to be limited, but this was an error; four days later, all the skin on the outer side of the stump was sphacelated; gangrenous abscesses formed in the thigh, and the patient died eighteen days after the operation.†

Perhaps this recrudescence of the gangrene might be charged to the delay in amputating; at least I was more successful under analogous circumstances. A woman of sixty-five, in good health and of strong constitution, had been thrown down by a dray, and had the tissues and the bone of her right arm crushed, the leg of the same side sustaining also a comminuted fracture near the ankle. This second fracture communicated with the air only by a very small wound situated at the outer side of the lower third of the leg; but emphysema extending nearly up to the knee made me think amputation necessary; both the arm and the leg were therefore removed some hours after the accident. On removing the dressings of both, on the third day, the arm was doing wonderfully well; but all the skin intended to form the stump of the leg was gangrenous. However, the gangrene went no further, and I had the satisfaction of curing my patient.

Still it must be confessed that along with these very frightful cases, there are others in which spontaneous emphysema assumes the mildest form in the world. I cannot say what occurred in the three successful cases seen by M. Velpeau, whether or not they presented symptoms such as have been mentioned. But M. Martin relates a case of emphysema of the upper extremity extending up to the chest, complicating a gunshot wound of the forearm, but without fracture. Except some counter-openings which were thought necessary, the emphysema was productive of no trouble, and gradually passed off. Might we not suspect that in this case the emphysema began in the thorax, thus completely explaining its harmlessness?

* Martin, *De l'emphysème traumatique; Gaz. Médic.*, 1836, p. 343.
† *Journal des Conn. Médico-Chir.*, Oct. 1840, p. 148.

On the whole, spontaneous emphysema in fractures is one of their gravest complications, and almost always calls for primary amputation. How is it caused? Whence comes its fatal effect? These are two difficult questions. In a case of crushing of the foot in which M. Simonin had performed Chopart's amputation, the patient died on the fourth day; and there was observed just at the time of his death an enormous emphysema of the leg. At the autopsy, a candle being held to the gas forming the emphysema, caused it to take fire with a slight report, and with a blue flame. Another case, in which death ensued twelve hours after a fracture of the skull, presented the same phenomenon.* But these two persons being both much addicted to the use of spirituous liquors, M. Simonin had ascribed to this habit the modification of the solids and fluids which gave rise to the emphysema; this, moreover, as far as we are informed, was only perceived after death.

I think for my own part that there occurs in the tissues, under the influence of the shock and stupor, a special alteration affecting their vitality, just as excessive cold kills the germ in the egg, and destroys the life in a clot of blood, without any change appreciable to the sight. The exhalation of a more or less deleterious gas is the only indication of this, and this symptom almost always points out the imminent approach of gangrene. I have sought to investigate the nature of these gases; in a subject affected with spontaneous gangrene, from a lesion of the soft parts of the thigh, death having taken place on the fourth day with mortification of nearly the whole limb, the emphysematous parts were opened two hours after death, and emitted a gas which took fire from a candle, burning with a bluish flame. Four hours afterwards, M. Joffroy collected at my request a quantity of this gas sufficient for analysis, and recognised it as carburetted hydrogen, mixed with not more than one-fifth of atmospheric air. I inquired besides carefully into the habits of the deceased, and learned that he had been remarkably sober.†

Is this gas, collected after death, identical with that of emphysema during life and before gangrene occurs? Would the same gas be always exhaled; or are there different sorts, corresponding to the different degrees of alteration present, and thus explaining the occasional mildness of the symptoms consecutively induced? Further observation alone can enlighten us in this respect.

Such are, on the whole, the six great indications for primary amputation, and there is not one of them which has not sometimes been remarkably set aside. To say precisely when they are to be rigorously followed, and when we may depart from them with safety, seems to me to be impossible; each surgeon must decide this from his own experience.

* E. Simonin, *Décade chirurgicale*, Paris, 1838, obs. 1.

† See my *Journal de Chirurgie*, April, 1845.

(2.) *Of Cases Calling for Secondary Amputation.*—These are chiefly extensive suppurations, dissecting up the muscles and bones, invading the joints, and threatening daily to spread higher;—extensive gangrene of the soft parts;—necrosis or caries of a large portion of the fragments;—an enormous diffused aneurism;—the occurrence of tetanus. I have already said how uncertain a resource amputation is in this last case, and the other indications also are often open to quite different interpretations at the bedside. Besides, they do not belong more essentially to fractures than to other lesions.

(3.) *Of Cases Calling for Consecutive Amputation.*—There are of these three principal ones, viz., pseudarthrosis resisting all treatment;—an irremediably deformed callus, making the limb a burden and hindrance to the patient;—disease of the callus, known to be incurable, or indefinite in its duration, such as the successive exfoliation of splinters during ten or fifteen years. Here the surgeon incurs a still greater responsibility than in the preceding cases; for while in them amputation was the only chance of safety, here life is not threatened, and it is amputation which would endanger it; in a word, it is an operation of complaisance.

I must not omit here a remark which is not without importance. In amputating for obstinate pseudarthrosis, the upper fragment has generally been sawn through. I think there would be a real advantage in amputating directly at the false joint itself; we should thus at least avoid the risk of inflammation of the medullary tissue, the central canal of the bone being obliterated at the extremity of each fragment.

CHAPTER II.

OF FRACTURES OF THE UPPER JAW.

The upper jaw comprises the majority of the bones of the cranium and face. We are not concerned here with fractures of the skull, the gravity of which depends wholly on the lesion of the brain, and the study of which is connected essentially with that of wounds of the head. But before passing to fractures of the facial bones, I would say a few words touching an extremely rare injury, which attracted particularly the notice of the ancients; fracture of the auricular cartilages.

Hippocrates and Celsus speak of it as a fracture; Galen thought this term improperly applied to it; Paulus Ægineta mixed it among contusions, and it is passed over by subsequent authors. I was therefore strongly disposed to believe that Hippocrates had had in view only contusions or lacerations of the ear, when recently M. Ménière has spoken of actual fracture of the cartilage.

"The muscles, the cellular tissue and the fibro-cartilage forming the pavilion of the ear," says he, "quite frequently undergo a form of alteration in virtue of which they become hard and stiff, so much so that this organ may be fractured, as I have seen it in a man thirty-eight years of age."*

I have given this passage *verbatim*, not without regretting the excessive conciseness of the author.

The fractures of the bones of the face which will form the subjects of the succeeding sections, are those of the zygomatic arch, malar bone, nasal bones, and upper maxillary bones. All these bones are joined together, forming as it were one solid block; they are at the same time united to the bones of the cranium; hence there are some characters, common to all their fractures, which may thus be summed up:

They are almost always the result of a direct blow;—their essential sign is depression;—and they are frequently complicated with concussion of the brain.

* *Gazette Médicale*, 1841, p. 530.

§ I.—*Fracture of the Zygomatic Arch.*

This fracture is very rare; Duverney was the first to speak of it. I have never myself met with it, and have only been able to collect five cases; even these are not all free from doubt.

It is usually the result of violence from without, a direct blow, or a fall; Duverney however relates the case of a young child who, having in his mouth the end of a lace-bobbin, fell head-foremost, so that the end of the bobbin, piercing the soft parts, broke the zygomatic apophysis from within outward. Can it not also take place from an indirect cause? M. Tavignot exhibited to the *Société Anatomique* the cranium of an epileptic subject, who having during a fit received a violent contusion on the left side of the forehead, died on the fourth day, from injury of the brain. The autopsy showed a single fracture of the zygomatic apophysis, without displacement; it had not even been suspected during life.*

Thus the fracture may be simple and without displacement, when the seat of the pain will be the main ground of the diagnosis. More commonly there are one or more splinters detached in the direction of the external violence. In the child mentioned by Duverney, the fragments projected outward; he says in fact that *the palm of the hand being applied over the cheek with slight pressure, the zygomatic apophysis was restored to its place.* In all the other cases, there was depression of the fragments.

[Henry Buck, aged 50, a colored sailor, was admitted into the Pennsylvania Hospital, in 1855, suffering from the consequences of the falling of some chain on his head and left shoulder, several months before. He had a fracture, firmly united with deformity *outward*, of the left zygomatic arch.]

This fracture is in itself a trivial affair; at the most it may somewhat impede the functions of the temporal muscle. A more serious danger arises from the concussion of the brain produced when the external violence is not exhausted in the fracture itself; as is shown in M. Tavignot's case.

But when the brain is uninjured, should we at once elevate the depressed fragments, and if so, by what means? Assuredly, if the integuments are intact, and the temporal muscle plays freely and without pain, the wisest plan is not to interfere. Under other circumstances we must do something, and two methods have been proposed.

The first is very simple, and could be applied in all cases, if its efficiency were better proved. Duverney explains it as follows: A soldier having been struck with a piece of wood, swelling of the en-

* *Bulletins de la Soc. Anat.*, 1840, p. 138.

tire cheek ensued, with great difficulty in either dropping or raising the jaw. "I examined the zygomatic apophysis," says the author, "and felt beneath my finger a depression. I introduced my left forefinger into the mouth; pushing it on as far as possible above the first molar teeth, and at the same time from within outward, I ascertained by the touch that the apophysis was broken and driven in. As there was no way of elevating it or pushing the fragments outward, either with the fingers or with other instruments, I advised the patient to take a somewhat flattened bit of wood about as big as his finger, to carry this far back above the molar teeth, and to close the jaws as firmly as possible. Having done this for some hours, he felt some relief; he kept on, increasing the size of the bit of wood, and by this means the pieces resumed their place, being pushed outward solely by the contraction of the temporal muscle."

I would not deny that this result was obtained; but several points in the account need explanation. It suffices to examine a prepared skull, or to carry one's finger into one's mouth, to show that the zygomatic arch cannot be reached in this direction. Again, the muscle is less in relation with the arch than its tendon is, and even this is separated from it by a special cushion of fat. Probably those motions really disengaged the tendon, but without effecting complete reduction; at all events, in such a case, there could be no objection to resorting to a plan so entirely innocent.

M. Ferrier employed more energetic means. A porter loaded with a sack of coal fell upon his right cheek, the load coming upon the other cheek. He came to the hospital at Arles with a depression on the right side of the head, which was recognised as a fracture of the zygomatic arch, the fragments being driven in. M. Ferrier made an incision three lines long through the integuments, and attempted to pass the small end of a spatula under the broken ends; but the temporal aponeurosis was in the way, and had to be in its turn cut through. The spatula then entered very easily, and by a to-and-fro movement the pieces were brought to their natural level. The little wound healed promptly; the patient was discharged on the seventh day, but the cure was perfect, and there was no deformity.*

Dupuytren seems horrified at such an operation; he once used an elevator, but it was through a wound which complicated the fracture. Inflammation ensued; deposits of pus, making their way along the coronoid process, opened into the mouth; however, the patient was cured in six weeks, without deformity or any hindrance to motion.†

It is quite evident, and Dupuytren himself remarks it, that these symptoms were caused by the violence of the blow; and nothing is proved against M. Ferrier's operation. Nevertheless, I repeat, it

* Rolland, *Obs. d'une fract.*, etc.; *Bulletin des Sciences Méd.*, tome x, p. 160.

† Dupuytren, *Leçons Orales*, second ed., tome ii, p. 202.

should not be resorted to unnecessarily; but the indications once clearly made out, I would not hesitate a moment.

§ II.—*Fractures of the Malar Bone.*

This name is given to cases in which the malar bone is driven in, whether it be simply luxated from the surrounding bones, which may very well occur, or there be an actual fracture; but it is very difficult to ascertain whether it is the edges of this bone, or those of its neighbors which are involved.

The instances of this injury are rare; to produce it the blow must be very severe. Sanson states that he has several times seen it caused by the kick of a horse, and that there could almost always be felt on the bone an indentation, the trace of the iron shoe.

The depression of the bone is a pathognomonic sign of this lesion; but it may easily be seen that for the first few days the contusion and consequent swelling will mask the depression, rendering the diagnosis very obscure or even impossible. Some other phenomena may then guide the surgeon, if the displacement is sufficient to cause compression of the infra-orbital nerve. Of this the following case was a remarkable instance.

Pierre Saintot, a joiner, thirty-four years old, came into my wards at Saint-Louis, September 13, 1837. Eleven days before, he had received from an awkward workman in his shop a violent blow on the right cheek with a very large two-handed mallet. He did not become insensible; but there ensued at once such swelling that his physician perceived only the contusion, and ordered venesection, and leeches to the part. He therefore applied to us only after the swelling had subsided.

I easily recognised a fracture of the malar bone, with depression. The cheek of the right side was perceptibly less prominent than that of the left; four millimètres above the outer and inferior angle of the orbit, this bone jutted forward about four millimètres; toward the zygomatic arch, it was on the contrary as much driven in, and the posterior portion of the arch consequently projected outward; lastly, passing the finger along the lower edge of the orbit, there was met an abnormal prominence, painful, but too deeply buried by the swollen tissues for me to say to what bone it belonged. The finger, carried through the mouth into the temporal fossa, could distinguish no trace of the fracture. On the whole, it appeared that the blow had driven in the posterior half of the malar bone, raising and carrying forward its anterior part.

From the first moment, he had lost all sensation in the right half of the upper lip, and in a triangular space, whose base was formed by this and its summit by the infra-orbital foramen. The ala of the

nose, and the gums, partook of this insensibility; as did also the upper teeth on this side. The mobility, on the contrary, was unaffected. When he chewed, he felt some pain in the anterior part of the temporal fossa, opposite the fracture; never in the masseter muscle.

The day after his admission, I attempted to push the bone outward by carrying my finger through the mouth into the temporal fossa; but my efforts were entirely futile. Six days afterwards, the patient insisted on another trial being made; this, although more force was used, succeeded no better, and moreover gave rise to swelling of the cheek, and to pain; these however subsided in a few days. The sensibility gradually returned; and on September 30, when I last examined him, he had feeling in all the teeth, and a little in the ala nasi; the numbness still continued in the other parts.

It is seen that in this patient the depression was irregular, involving only the posterior part of the bone. A superficial examination, or one obscured by swelling of the soft parts, might in such a case lead to error, making us consider the fracture as involving merely the zygomatic arch. It seems to me that Dupuytren himself made this mistake. An old man of seventy had been thrown down by a carriage; a contused wound at the external angle of the eye showed that the principal shock had fallen on this point; the patient was carried to the Hôtel-Dieu, insensible. At his evening visit, Dupuytren thought he recognised a fracture of the zygomatic arch. Death ensued on the fifth day. At the autopsy the arch was found to be really fractured, but there was at the same time a depression of *the part of the upper maxillary bone forming the sinus maxillare*, which would seem to me to be nothing more or less than the malar bone.*

When this fracture is attended with concussion of the brain, it disappears, so to speak, before the graver lesion which engages the surgeon's whole attention. In the simple form, it requires no other manipulation than what I used in my patient; but we should remark the rapidity with which it becomes irreducible, all our efforts having failed on the twelfth day.

I have seen another instance of fracture of this bone with quite opposite characters, but from a different cause. In one of the old men under my care at Bicêtre, I was struck with the unnatural prominence of his left cheek-bone, and asked him the cause of it. He was an old soldier of the empire; at the affair of Ulm, an Austrian hussar had given him a sabre cut which, crossing the cheek obliquely from the left ala nasi to the external angle of the eye, had divided the malar bone and thrown it strongly outward. At the lower border

* Dupuytren, *Leçons Orales*, second ed., tome ii, p. 205.

of the orbit, the bone projected about five millimètres, and seven or eight millimètres at the outer border. The cheek-bone was thus made to project notably, while the temporal seemed on the contrary much deepened. The left eye had at first lost some of its power, but afterwards regained it. The only remaining annoyance was that the eyelids did not come into perfect contact, even in winking; during sleep they were widely separated. Thus, while in the preceding case the depression of the bone had acted specially on the infra-orbital nerve, it was here the filaments of the facial, divided by the sabre, whose functions were impaired.

§ III.—*Fractures of the Nose.*

These are the most frequent of any of the fractures affecting the upper jaw; yet they are very rare, since in the space of eleven years only twelve were received at the Hôtel-Dieu. One only was observed in a woman; so that this fracture is one of those which occur mostly in the male sex. All ages are subject to it, except perhaps early infancy; the youngest of our twelve cases was thirteen years old, and the oldest sixty-eight.

The causes are falls on the face, or more commonly severe blows given from in front or from one side.

These fractures present several varieties. Hippocrates, besides fractures of the bones, admits those of the cartilages, and we shall see hereafter several instances where they seem to have been at least separated from the bones.

J. L. Petit teaches that commonly but one of the bones is broken, the other being merely driven in, especially in persons who have the root of the nose flattened. Duverney on the contrary says that generally both bones are broken. Facts are wanting to prove this relative frequency, and at any rate the question is of but small importance. A more essential distinction was made by Hippocrates; sometimes the fracture is slight, without displacement, and may be treated as a contusion or a simple wound; or there may be notable displacement, and then, according to the direction of the blow, the fragments are driven directly in or pushed to one side. An instance of this second form of displacement is seen in *Fig.* 13. The fracture has separated nearly transversely the lower portions of the nasal bones, and a very small portion of the ascending process of the right upper maxillary; the fragment of the nasal bone of the left side has been forced to the right and a little backward, separating from the upper portion, which thus projects notably above, and without parting from the ascending process, the suture of which has also changed its place. The fragment of the right nasal bone has been divided again by a vertical split; its inner part, pushed to the right

and a little forward, is placed on the same plane as the lower fragment of the left nasal bone, so that the angle which they naturally form together has almost entirely disappeared; and another very marked angle, well seen in the figure, is formed by this part of the right fragment with its other part, which is slightly turned aside. This is moreover the only example of this fracture which I have been able to find in the museums of Paris.

Fractures of the nose are often attended with great contusion or even wounding of the integuments. Commonly a slight flow of blood occurs from the nostrils; sometimes it amounts to a hemorrhage, and Rossi says that he has seen it prove fatal before he had time to save the patient; but this is most extraordinary. A rarer, but at the same time much less serious symptom, is emphysema. A young man had received a violent blow on the nose, without any other symptom at first than a quite severe pain; but some hours afterwards, blowing his nose forcibly, he felt something like a flash of fire pass up the nose toward the left eyelid, which immediately became puffed up with emphysema. Dupuytren was of opinion that the air had entered by a rent in the mucous membrane opposite the union of the left lateral cartilage with the bones of the nose, which union had been destroyed.

Besides these primary symptoms, others sometimes supervene as consecutive phenomena; thus, in the first place, the inflammation may go on to abscess, sometimes showing itself between the mucous membrane and the bone, sometimes beneath the skin, sometimes in both places at once; of this J. L. Petit relates instances. If the suppuration be prolonged, it may induce partial necrosis. The consequences attributed to these fractures do not cease even here: Monteggia quotes, from a medical journal which I have not been able to find, a case in which a fracture of the nose seemed to be the determining cause of a fatal polypus; but here we should perhaps recognise a predisposition more serious than the mere fracture. The following observation, taken from Duverney, shows how deplorable may be the consequences of fracture of the nose in some subjects.

A woman having received a blow with the fist on the right side of the nose, enormous swelling ensued, which obscured all the symptoms of fracture. The bleeding from the nose was excessive; the menses, which were flowing, were checked; the nasal mucous membrane swelled so as to form a plug, filling up the entire entrance of the nostril. At the end of fifteen days a fluctuating tumor was observed near the inner angle of the eye, which being opened, there flowed out some very putrid liquid blood. The nasal bone was laid bare, and a small portion of it, separated from the cartilage, was removed. The patient was nearly well when a fistula lachrymalis was formed, on which Woolhouse operated. Some days after the operation, there sprang up a fungous mass, which could not be kept down, but

degenerated into cancer, and the woman perished after terrible suffering.

I have so far alluded only to fracture limited to the nasal bones; it is easily seen that the external violence will not always stop at this. Quite commonly part of the ascending process of the upper maxillary bone is included in the fracture, without adding at all to its gravity; it was so in the case represented, and I have seen another instance in the living subject.

A painter, thirty-one years old, fell twenty feet off a ladder, and crushed his nose on the pavement. The fracture was compound; several incisions had to be made for the extraction of splinters, and the cure was not complete till after four months. I had occasion to examine it sixteen years afterwards; a large cicatrix reached from the left nostril to two fingers'-breadth above the eyebrow; the bones of the nose were almost completely driven in, so that there were evident under the skin two lateral prominences nearly three centimètres [one inch] apart, which were the ascending processes; the process of the left side presented also distinct traces of a fracture; nevertheless, respiration was freely performed through the nostrils, and the patient had never had any epiphora.

But if the fracture involves the nasal canal, there is reason to fear a very intractable fistula lachrymalis. Of this Boyer relates a case:—

"A girl eight years old was kicked by a horse, causing fracture of the nose, with depression. There ensued considerable swelling and inflammation, which were treated, with a view of dissipating them entirely before proceeding to reduction. These symptoms went off; but now reduction was impossible, so that the nose remained flattened, and an incurable fistula lachrymalis ensued, from the injury to the nasal canal."

It has been thought also that a fracture involving the bones of the nose might in some cases extend to the perpendicular and cribriform plates of the ethmoid. According to J. L. Petit, *there ought to be* fracture of the perpendicular plate whenever the blow falls perpendicularly; or if this plate resists, there should be concussion of the brain. Others have thought that the resistance of the perpendicular plate gave rise to fracture of the cribriform, which, according to Boyer, has been sometimes observed. We have not facts enough to decide positively as to these statements. But at all events, fracture of the nose is unhappily often complicated with fracture of the skull or concussion, like fractures of the other facial bones.

The diagnosis is sometimes very difficult, even when there is notable displacement, on account of the swelling; if there is no displacement, it becomes almost impossible. I discovered by chance, in an autopsy on a young child, one of these fractures without displacement; it had not even been suspected during life. In such a case, as is easily seen, the error would be trifling.

The prognosis is generally favorable. Whether simple or compound, most fractures of the nose are quickly cured. Hippocrates fixes the term for their consolidation at ten days, which may perhaps be a little too short; but Boyer's case, related above, shows with what rapidity the displaced fragments contract adhesions which render reduction impossible. The bones have so much vitality as to unite, so to speak, by the first intention; in the specimen represented in *Fig.* 13, we see no traces, either inside or outside, of any osseous deposit indicating provisional callus; and the vertical fracture of the right fragment, like the median suture of the two fragments, is healed so as to leave almost no sign of any separation.

The treatment varies in different cases. If there is no notable displacement, or if the fracture is such that no tendency exists to its reproduction after adjustment, we should apply no apparatus. The slightest bandaging compresses the fragments painfully, and is at any rate useless. L. Verduc was called to see a young surgeon who, he says, had luxated one of the nasal bones by a fall; as he judged from the nose being twisted. To replace the bone, a little stick wrapped in a linen rag was introduced into the nostril with the right hand, pushing the bone strongly upward; while the left thumb was pressed upon the root of the nose; reduction was effected with a slight noise, and the cure was accomplished without any apparatus.

When, however, the crushing is such that the displacement tends to recur, some means of retention becomes necessary. No author that I know of has treated this subject so much at length as Hippocrates. He insists first on the reduction, and the adjustment of the nose without and within. The process is the same in all cases, consisting in carrying into the nostril a finger or some other instrument, to push up the fragments, while with the fingers of the other hand they are coaptated from without. This reduction is easier during the first few days than later; nevertheless, to succeed in it, a certain amount of force must be employed. Hippocrates reproves the timidity of the surgeons of his time in regard to this, and that of the patients themselves, who would pay so dearly to avoid any deformity, and yet would not consent to what was necessary. These reflections, old as they are, are not the less applicable in our own times; and I have seen several fractures of the nose, the deformity from which testified to all eyes either the surgeon's fault or the patient's indocility.

The reduction accomplished, Hippocrates covered the nose with a glue made of flour from March wheat, which was regarded as preferable to any other; and if this was not sufficiently adhesive, there was mixed with it some very finely powdered olibanum, or a little gum. The object would seem to have been to fasten the nose to an exterior mould solid enough to keep it in form. In order more effectually to hinder the giving way of the fragments, there was placed within each nostril some charpie, or some analogous material, wrapped in

linen or sewed up in morocco; this was very flexible and soft. Singularly enough, these foreign bodies were only used in fractures of the lower portion of the nose; it was thought that in fractures toward the root their presence would be unendurable. Hippocrates would also have had the patient use sufficient firmness to keep his own fingers applied over the nose, so as to maintain coaptation; or if he could not, that it should be done for him by a woman or a child; and he says that he has never seen a fracture of the nose which could not be perfectly united by these means. In ancient Greece, where beauty even in the male sex was in a manner worshipped, we can understand that such precautions might have been observed; in our day certainly few patients would submit to them, and they are passed over in silence by all modern surgeons. We may easily imagine, however, a case of fracture of the nose occurring in a woman proud of her beauty, in which they would not be without value.

Lastly, if there were any tendency to lateral deviation in the nose, it was attempted to keep it in place by means of strips of leather smeared with glue, like our adhesive strips.

After the time of Hippocrates, the idea was conceived of placing in the nostrils, instead of charpie, quills wrapped in some soft substance; Celsus makes mention of them. Paulus Ægineta speaks of another apparatus applied on the outside by some surgeons, in compound fractures, to prevent exuberance in the granulations; it was simply a leaden cap fitted to the nose.

I have dwelt thus carefully on the therapeutics of the ancients, because the moderns have merely followed after them, not even meeting the indications so completely. The modifications made in the apparatus have been unimportant. Avicenna substituted for wheat-glue that from fishes, or even strong glue, *glutinum corii vaccini;* Albucasis used flour and white of eggs, etc. As to the tubes introduced into the nostrils, Lanfranc made them of wax, mastic, and dragon's-blood, like bougies; A. Paré preferred them made of gold, silver, or lead; Boyer recommended them of india-rubber, kept in the nostrils by charpie placed around them like a tampon.

These means have not, however, met with universal favor. J. L. Petit rejects them altogether, on the ground that more force is necessary to re-displace the bones after reduction than to reduce them; and asserts that those who invented them had never reduced one of these fractures.

I apprehend that J. L. Petit has here relied too blindly on his own experience, undervaluing that of others. Marchetti relates the case of a merchant of Padua who, by a blow with a large piece of wood, had the bones of the nose reduced to fragments as small as grains of wheat; he says that he kept them up first with a tent, and afterwards with a quill; and still later, to favor the cicatrisation of the soft parts, with a leaden canula. Saviard treated a young man who

had a wound of the nose, with fracture, and such great depression of both bones that their lateral portions, where they joined the ascending processes, were more prominent than their inner edges; the bones were likewise so detached at the sides and from one another, that they could easily have been extracted with a pair of forceps. He thought proper to support them by means of hollow tents, and in fifteen days the patient was cured without deformity.*

These canulas are generally fixed by means of bands going to the cap of the patient. Brambilla has represented an apparatus, recommended also by B. Bell, consisting of two metallic tubes, each supported on a slender flat stem; these stems are fastened to a metallic plate applied over the upper lip, this again being retained in place by means of two bands tied behind the head. A. Dubois resorted, in a difficult case, to an apparatus still more complicated, but of greater efficacy.

This was composed of a semicircular metallic plate embracing the face from one temple to the other, passing over the upper lip, and jointed with another which went round the occiput. Two bands, passing over the head and nape of the neck, kept these two semicircles at the proper height; and lastly, upon the anterior semicircle, above the lip, was fixed a fork, having two rounded, blunt tines, suitably covered, and intended to enter the nostrils, one going on each side of the septum. This fork being hinged on, and moved to and fro by a screw, tended to raise up the nasal bones as much as was required, while a free passage was maintained for the respiration. The use of this machine was always successful.†

Here, as in everything else, we are to be governed by the indications; if there is no danger of displacement, I have already said that we are not to interfere; if there be any tendency that way, the use of canulas or of Dubois' apparatus becomes indispensable.

It is not only fractures with depression which must be thus kept in place, but sometimes also fractures with lateral deviation. M. Royère relates an instance in which he was obliged to resort to a special machine. An officer, twenty-four years old, having fallen from a height of about four mètres, [about four and a half yards,] on the right side of his face, sustained a compound comminuted fracture of the nasal bones, with deviation of the fragments toward the left side. M. Prat, surgeon-major, performed reduction and applied a compressing bandage; but this bandage soon became relaxed, and then the displacement at once recurred. On the tenth day, the wounds had cicatrised, but the tendency of the nose to deformity persisted. M. Royère devised an apparatus composed of a curved iron band, kept applied to the forehead by means of straps; from

* Marchetti, *Sylloge Obs. medico-chir. rariorum*, obs. 28; Saviard, *Recueil d'observ. chirurgicales*, obs. 107.

† Gerdy, *Traité des bandages*, second ed., p. 468.

this there came off a branch with a well-padded plate at its extremity, which plate acted on the left side of the nose, pushing it over to the right. The nostrils were stuffed with charpie during the application of this machine, and consolidation occurred in forty days.*

I do not know how far such an apparatus might become essential; and I am strongly inclined to believe that if adhesive strips, not liable to relaxation, are insufficient, the application of a leaden cap exactly fitted to the nose would be at once the simplest and surest remedy for lateral deviations.

So much for displacements. Let us now say a word concerning complications. Emphysema will disappear of itself, and requires no treatment. Hemorrhage may be combated first by the usual means, cold lotions, or applying some cold body between the shoulders. Raising the arm up, as advised by M. Négrier, was once successfully used by M. Pangue. A young man had been thrown down with his face to the ground, and presented a fracture of the nose with copious bleeding. Cold lotions having failed to check the latter, M. Pangue made him raise his arm up perpendicularly; the hemorrhage ceased immediately, and did not recur.†

The complication of a wound is but trifling; if the fracture is comminuted, we must accomplish as much by the first intention as possible, and not remove any splinter until it is entirely separated. If an abscess occurs near the fracture, the rule laid down by J. L. Petit is to open it through the mucous membrane, and to make no incision in the integuments except in case of absolute necessity.

When the fracture has united with deformity, it is impossible to correct the deviation of the bones; but we may sometimes do this in the case of the cartilages. M. Dieffenbach had to treat such a deformity resulting from a fall; the nose was so displaced as to lie against the cheek, one nostril being upward and the other downward. He passed a tenotome under the skin, outside the nostril, divided the alar and dorsal cartilages at their junction with the bones, then did the same on the other side and in the septum, so that the cartilaginous part of the skeleton of the nose was perfectly movable, and could be brought back to its proper place. The cure is said to have been perfect.‡ Admitting some little exaggeration in regard to the result, this operation is none the less ingenious, and would afford a valuable resource in case of need.

§ IV.—*Fractures of the Upper Maxillary Bones.*

These fractures, which are very rare, and have hardly been at all studied until the present time, offer numerous varieties, differing

* *Recueil de Mém. de méd., chir., et pharm. militaires*, tome viii, p. 286.
† *Journ. de médecine et de chir. pratiques*, 1843, p. 423.
‡ *Gazette des Hôpitaux*, February 22, 1842.

much in gravity. If a piercing or contusing instrument breaks at any point the outer wall of the maxillary sinus, the fracture hardly adds at all to the trifling danger of the wound of the soft parts; such perforations are sometimes made intentionally by the surgeon. When in drawing a tooth the wall of the alveolus is broken, it is an affair of no more moment; but it is otherwise when a blow or severe pressure from without detaches a portion of the alveolar arch, drives in one or both of the maxillary bones, and displaces at the same time nearly all the facial bones.

When a fragment of any size has been detached from the alveolar arch, it is important to keep it in proper position in reference to the rest, so that all the teeth may remain at the same level. Here we may apply, with some modifications, most of the dressings devised for fractures of the lower jaw.

Ledran tried with success the ligature of the teeth in a man who, having fallen under a wagon-wheel, had had the four last molar teeth and the corresponding part of the alveolar arch displaced into the mouth and up against the palate, neither the palate nor the gums, however, being at all torn. The fragment was movable, working from side to side with the different motions of the cheeks and tongue. Ledran conceived of fixing the teeth by a ligature, and called in the dentist Capron. He fastened with a large thread the four detached teeth to the fifth, which was still firm, and they were thus tightly held. The threads came away at the end of ten or twelve days, but consolidation was sufficiently advanced to make them unnecessary; and by the thirty-fourth day the man was entirely well. I would add that this person had at the same time a fracture of the lower jaw, which was cured by the same process.

[There was in September, 1857, in the Pennsylvania Hospital, a patient who had fallen from his wagon on his face, a heavy box coming down on his head as he lay. With excessive contusion of the soft parts, there was a fracture of semicircular form involving the anterior alveoli of the upper maxillary bones, and of course detaching the incisor teeth. The lower jaw was also broken in two places. All these three fractures were treated by the wire ligature, which I may mention here is commonly used in this country in all cases where the slightest difficulty is encountered in fixing the fragments by other means. The case alluded to did not do very well, the patient being very intractable.]

Alix had the like good fortune in an almost entirely similar case. A carriage-wheel, passing over a woman's head, had driven in the canine and two molar teeth* of the right side, with their alveoli. Alix had thought of removing the fragment; but, encouraged by Ledran's success, he readjusted it, attached the canine tooth to the

* [In French works on anatomy the bicuspid teeth are called lesser molars, (*petites molaires.*)]

neighboring incisor with a loop of wire, twisting the ends with forceps; he fastened the molar teeth in the same way, only taking care in each case to guard the lips from irritation by the ends of the wire by means of a small compress. On the twelfth day he removed the wire from the canine tooth, on the fourteenth that from the molars; and in three weeks the cure was complete.*

In a similar case, Graefe gave the preference to an apparatus modeled upon that of Rutenick for the lower jaw; it is deserving of special mention.

A curved steel spring, properly padded, is applied over the forehead, and kept in place by a strap buckled around the occiput. This spring has at each side a hole, with a screw for making pressure; and a steel brace, to which it affords a *point d'appui* for acting steadily on the dental arch. Now these braces, descending to the level of the free edge of the upper lip, curve backward so as to go around the lip without wounding it; getting thus at the dental arch, they again curve so as to apply themselves to it. But as the pressure of the braces should have the effect of keeping the detached teeth in proper relation with the rest, a silver trough duly padded is made to fit over both to a sufficient length; and upon this trough the braces exert their pressure. It is easy to see how, by altering their height as regards the spring over the forehead, the pressure may be regulated to the right degree.†

The simultaneous driving in of both bones cannot occur without numerous disjunctions of the sutures, or else fractures, of the facial bones. I know of but one case, which was observed by Wiseman; and he encountered such unheard of difficulties in replacing and maintaining the bones in position, as to give the case a peculiar interest.

A little boy eight years old had received on the middle of his face so violent a blow that he had seemed at first dead, and afterwards lay in a prolonged coma. "When I saw him," says the author, "he presented a strange aspect, having his face driven in, his lower jaw projecting forward; I knew not where to find any purchase, or how to make my extension. But after a time he became sensible, and was persuaded to open his mouth. I saw then that the bones of the palate were driven so far back that it was impossible to pass my finger behind them, as I had intended; and the extension could be made in no other way. I extemporised an instrument curved at its extremity, which I engaged behind the palate, and having carried it a little upward, used it to draw the bone forward, which I did without any difficulty; but I had hardly withdrawn the instrument when the fractured portions went back again. I then contented myself

* Ledran, *Obs. Chirurgicales*, tome i, obs. 3; Alix, *Observata Chirurg.*, Altenburg, 1774, fasc. i, obs. 11.

† See Richter's *Atlas*, Tab. vi, fig. 4.

with dressing the face with an astringent cerate, to prevent the afflux of the humors; I likewise prescribed bleeding; and some hours afterwards, I had an instrument better constructed to reduce the large mass of displaced bone to its proper position; I had it held by the child's hand, by that of its mother or of an assistant, each for a certain time; nothing else was done. Thus by our united attention, the tonicity of the part was maintained; the callus was developed, and in proportion as it became solidified, the parts became stronger, the face assumed a good appearance, certainly better than could have been hoped for after such marked displacement; and the child was entirely cured."

It would be more convenient, in such a case, to fix the brace in front of a sort of mask sufficiently removed from the level of the face, cut for instance like the visor of a helmet or a fencing mask.

I have found likewise but a single case of depression of one of the upper maxillary bones; it will be seen that this could not occur without disjunction of the median suture, and fractures at various other points. The mobility was however much less than in Wiseman's case; and nature at length made the reduction almost without assistance. This case, which is also a very curious one, is due to M. Simonin, of Nancy.

A carpenter, twenty-one years old, having fallen from a height of two stories, presented, besides fractures of the arm and leg, and a luxation of the clavicle, the following condition of the face:—Simple fracture of the nasal bones, loosening of the incisor teeth from the alveoli above and below, separation to about nine millimètres of the upper maxillary and palate bones in their median suture, depression of the entire left side of the face without any alteration of the soft parts; besides a vertical fracture without displacement, near the symphysis of the lower jaw. There were no symptoms of concussion of the brain. A pair of forceps being introduced under the nasal bones with the right hand, they were pried up, while coaptation was accurately made with the left hand; the approximation of the upper maxillary and palate bones was attempted by means of lateral pressure, ligatures being also placed on the upper incisor teeth; but these teeth were so much loosened that they soon fell out; of the other fractures I shall say nothing. At the tenth day the inter-maxillary suture began to close; by the thirty-third day, the fractures of the nose and lower jaw were united without deformity, and the reunion of the suture along the palatine arch was complete; only the left upper maxillary bone remained slightly depressed, not however so as to interfere with either deglutition or talking; the other fractures also became firm subsequently.*

A still more severe blow might crush or carry off a part, or even

* Edm. Simonin, *Décade Chirurgicale*, Paris, 1838, obs. 9.

nearly all the facial bones, but not without proportional damage to the soft parts. It is generally large bodies driven by some explosive force, as balls or shells, which produce such fearful injuries. Larrey and Dupuytren have given instances of this; but they are more rarely seen caused by common blows; and in this respect I know of no case comparable to the following one, which I had occasion to examine a long time after the injury.

A young boy received in the middle of his face so violent a kick from a horse, that the nasal, upper maxillary and palate bones were greatly comminuted, and the integuments contused and torn. A cure was obtained, but with singular deformity. The nasal bones were destroyed; the anterior portion of the alveolar arch, and most if not all of the vault of the palate, had likewise disappeared. He had no nose nor mouth; the two lips being fastened together by a thick and firm cicatrix, the chin was continued up to an oval opening, formed between the two ascending processes of the maxillary bones as high as the frontal. By this one opening the patient breathed, spoke, ate and drank; when a piece of bread was put into it, the tongue was seen to come up, and to carry it down to the molar teeth, which performed their functions very well.

[A man was brought to the Pennsylvania Hospital in the fall of 1855, who had had his head caught between a hoisting machine worked by steam, and the floor, as he was looking over the side of the platform of the machine. The face was separated, bones, soft parts and all, from the cranium, as far back as the sphenoid bone; a ghastly gash across the face, with the curious falling of all the features away from the forehead, was the principal external sign. He died of the shock, in a few hours.]

Lastly, there is another cause of fracture of the upper maxillary bones, which acts from within outward; it is the firing of a pistol into the mouth with a view to suicide. Nothing presents greater variety than the effects so produced; but this is not the place to enumerate them. I shall mention however the observation of Hernu, as an instance of a very singular fracture. The charge of the pistol, consisting of two balls, had made a considerable opening about the middle of the hard palate; the two upper maxillary bones were separated, not only from one another, but also from the nasal and malar bones. All these parts were movable; but the only perceptible deformity consisted in a prominence made by the inner angle of the malar bone on the right side. The lower jaw was also fractured. An attempt was made to overcome the projection of the malar bone; but, although the accident had occurred only three days before, it was impossible to accomplish it. The only dressing used was a strip below the nose, to keep the upper maxillary bones together as much as possible. On the twelfth day, a small splinter was detached from the palatine arch, after which the perforation of the arch became

much contracted; by the fiftieth day the maxillary bones seemed united, and there remained no other external trace of the frightful destruction of parts than the enlarged nose and the prominence of the right malar bone.*

In compound fractures of the upper jaw, there is one principle which surgeons cannot too carefully bear in mind; this is, that all splinters, however slightly adherent, should be scrupulously preserved, as they become reunited with wonderful facility. This remark was made by Saviard; Larrey has strongly insisted on it;† and we have seen that M. Baudens, who so much urges the extraction of splinters, has likewise made a special exception of these cases.

* *Journal de Chirurgie*, Desault, tome iii, p. 236.

† Saviard, *loc. cit.;* Larrey, *Clinique chirurg.*, tome v, p. 94.

CHAPTER III.

OF FRACTURES OF THE LOWER JAW.

These, although more numerous by themselves than all those of the other facial bones together, are however not very frequent, since during eleven years but twenty-seven cases presented themselves at the Hôtel-Dieu. The excess of male cases is at least as marked as in fractures of the nose; thus, of those twenty-seven, there was but one woman. As to age, the youngest was fourteen, the oldest fifty-seven years; as to the season, two-thirds of the cases occurred in the summer-time, viz., from April to September.

A good many varieties of this fracture are recognised. M. Gariel has proved by an autopsy the existence of a fissure on a level with the dental canal, involving but part of the thickness of the bone.* Fractures of the alveoli, so commonly caused in the extraction of teeth, are usually of small importance; fractures of the rami are very rare. To tell the truth, I know of no case of the latter but that of Ledran, which was in a child of ten or twelve years; here the kick of a horse produced a fracture of the body of the bone, and another at the angle on the same side, extending obliquely from the root of the coronoid process to the neck of the condyle; there was so little displacement that this second fracture was only detected at the autopsy.† But the two great varieties which it is particularly important to recognise are those of the body of the bone, and those of the neck of the condyle.

§ I.—*Fractures of the Body of the Bone.*

The causes of these are nearly always direct, such as a fall on the chin, or a blow given upon the bone; a cause not unfrequently mentioned by observers is the kick of a horse on the front of the jaw. I have seen this bone broken in a young girl by a blow with the fist. We must, however, recognise an indirect cause, when violent pressure like that of a carriage-wheel tends to force together the

* *Bulletin de la Soc. Anatom.*, 1835, p. 24.
† Ledran, *Obs. Chirurg.*, tome i, obs. 8.

two sides of the bone; it does not need any excessive force to produce a fracture by this mechanism, as may be ascertained upon the dead body. Lastly, when a person fires a pistol into his mouth, the sudden development of gas is sometimes powerful enough to fracture the lower jaw; as took place in Hernu's case, before quoted. M. P. Bérard saw a fracture of the symphysis, resulting from the firing of a pistol loaded only with powder.

Most commonly the bone is fractured in but one place; sometimes it gives way at several points; comminuted fractures are more rare, and hardly occur at all except from gunshot wounds. As to direction, the fracture is sometimes vertical, and sometimes oblique; if the latter, according to Boyer, it usually passes downward and backward. But an important point to be noted is that very often the fracture divides the thickness of the bone obliquely; generally the obliquity is at the expense of the inner face of the posterior fragment, and the outer face of the anterior. (See *Fig.* 14.) This circumstance, which has hitherto been unnoticed, gives us the key to a good many displacements.

Can fracture occur at any point in the body of the bone? This question would seem a very strange one, had not Boyer stoutly maintained that the solution of continuity never took place just at the symphysis. Nevertheless, Hippocrates had pointed out this form of fracture with great precision, and modern experience confirms that of ancient times. Rouyer de Mirecourt ascertained that the symphysis was divided in a laborer whose jaw was affected with triple fracture; it was separated so exactly in the median line, that the two first incisors were not even loosened. Chollet has published an analogous case; I have before quoted that of M. P. Bérard. M. J. Cloquet has put an end to all doubt by demonstrating a division of the symphysis upon an anatomical specimen; MM. A. Bérard, Lisfranc, Leloutre, Bush, Houzelot, and Legros, have seen similar instances;* and lastly, I shall presently mention one observed by myself.

The distinctive phenomena of these fractures are pain, deformity, swelling, increased salivation, loosening of the teeth, and finally some symptoms due to lesion of the inferior dental nerve.

The only one of these phenomena which is constant is the pain. Often slight, but sometimes excessive, it is increased by the voluntary raising or lowering of the jaw, by pressure at the seat of fracture, by pressure at both angles of the bone, or by any manipulation which displaces the fragments.

The subject of displacements in fractures of the lower jaw has

* See *Journ. Gén. de Médecine*, tome lxiii, p. 4, and tome lxvi, p. 80; *Revue Médicale*, 1824, tome iv, p. 465; *Dict. de Médecine* en 30 vol., art. *Mâchoire;* and Houzelot, *Thèse inaug.*, Paris, 1827.

been discussed in various ways and with different conclusions, but always with the idea of the entire sufficiency of muscular action for their production; in regard to this there have been theories put forth by J. L. Petit, Boyer, Ribes, and Houzelot. I shall not stop to dispute these, but shall merely present the results of the facts.

Quite often there is no perceptible displacement. I have myself three times seen this, especially in the case before mentioned as caused by a blow from the fist; here the fracture was at some distance from the symphysis. Thus, then, in the first place, wherever the fracture may have occurred, if the periosteum be nearly or quite intact, there will be no displacement of any kind.

But if the external violence has disconnected the fragments by tearing the periosteum and the surrounding tissues, the muscular action will necessarily tend to reproduce the primary displacement, and sometimes to add to it, according to the seat, direction and number of the fractures; it must, however, be repeated, that this cause comes only secondarily, and cannot of itself induce displacement.

In simple vertical fractures, without obliquity of any kind, one of the fragments generally rises a little, so that the teeth are not on the same level; and there may be observed also a slight separation of the fragments toward their upper edge. Now which fragment rises, and which descends? This has seemed to me to depend on the direction of the blow, which is always felt somewhat more by one fragment than by the other. An epileptic at Bicêtre had in a paroxysm broken the jaw nearly in the median line; a severe laceration of the chin, a little to the left, showed that he had fallen on that side. The left half of the dental arch was some three millimètres higher than the right; there was a slight separation between the two middle incisors, which did not exist at the lower part of the fracture, and which was sensibly increased as the jaws approached one another, so that the free edges of the teeth even made an angle upward. M. Chassaignac saw the same phenomenon in a fracture passing vertically between the first and second incisor.* It is probable that in a fracture seated far back, the result would be quite different; that is, that the fragments would separate rather as the jaw was depressed than as it was elevated.

But when the fracture, although vertical, divides the thickness of the bone obliquely, there occurs an overlapping from before backward, and necessarily following the direction of the obliquity. Now since most generally, as I have said, the posterior fragment has its inner face bevelled off, this fragment must remain outside of the

* Neucourt, *Obs. de fract. de la mâchoire inférieure; Journal de Chirurgie*, 1844, p. 359.

anterior; and the greater the overlapping, the more it is displaced outward. A fine example of this is seen in *Fig.* 14; it is the jaw of a person who threw himself from a second-story window, and died instantly. Among many other fractures, I distinguished this, and shall presently use it in the solution of another problem. I had previously, in 1837, had an opportunity of demonstrating the mechanism of this displacement. A person was brought into my wards at Saint-Louis, having sustained various injuries by a wagon-wheel going over his body. The lower jaw was broken almost vertically between the canine and incisor teeth on the right side. The posterior fragment projected outwardly about six millimètres, and was also carried forward so that the canine tooth was five or six millimètres beyond the level of the second incisor; the chin, however, maintained its normal direction. The mouth was partly open, the teeth slightly separated, and the two fragments nearly on the same horizontal plane. I called the attention of the pupils to this case; and the phenomena observed were so different from those theoretically described, that several of them thought there was a double fracture, the median fragment being drawn backward. The patient dying of other and graver injuries, it was ascertained that the fracture was single, but its obliquity perfectly explained the nature of the displacement.

For want of attention to this obliquity, some surgeons, completely preoccupied with the idea of muscular action, have carried their love of theory so far as to contradict their own facts. M. Houzelot, for example, commences by proving that the posterior fragment should be drawn inward by the muscles; and a little further on he records two well-proven cases in which this fragment was thrown outward. I have already said, and I repeat, that the latter generally occurs; I have found but two cases in which displacement inward had been seen to take place: one, related by Manoury, concerned a fracture caused by discharging a pistol into the mouth;* the other is given by M. Baudens, and will be alluded to again hereafter.

The overlapping of the fragments is also accompanied, generally, by displacement upward or downward. I say generally, because in the instance mentioned above, as well as in the specimen represented in *Fig.* 14, this displacement is not perceptible. When it does exist, the posterior fragment is usually carried upward; it was so in M. Houzelot's two patients, and in one case observed by M. Jousset. But the contrary may occur; in another patient of M. Jousset's, the anterior fragment was somewhat raised.† What reason is there for such a difference? As in ordinary vertical fractures, this would

* *Journal de Chirurgie*, Desault, tome i, p. 8.

† Jousset, *Note sur un nouv. appar. pour le tr. des fract. de la mâchoire inférieure; Gaz. Médicale*, 1833, p. 222.

appear to me to depend upon an impulse given by the external violence to one or the other fragment.

As to fractures directed obliquely downward and backward, or downward and forward, they may occur, like others, without any perceptible displacement, or perhaps with a slight displacement increased by any motion of the bone. I presume, but have not had a chance to ascertain it, that if the fracture commences above, near the median line, the elevation of the jaw will cause a separation as in vertical fractures. But the following case seems to prove that the result is the contrary when the fracture is farther back. M. Gérard had to treat a fracture which ran obliquely downward and backward, commencing in front of the last molar, and terminating half an inch in front of the angle of the jaw. The fragments were hardly separated; but if the patient tried to open his mouth, the anterior fragment was drawn up, passing a little to the right, and the last two molar teeth presented a separation of two lines.* If the blow is forcible enough to produce notable overlapping, the direction of the latter is decided by that of the fracture, unless the bone breaks obliquely in its thickness; that is to say, if the fracture passes downward and backward, the posterior fragment rises over the level of the other, and *vice versâ;* but the existence of obliquity in the direction of the thickness of the bone will greatly modify this result.

Double fractures are amenable to the same laws; they present no displacement except that produced by the external violence. I have already quoted Ledran's case, of a child who had at the same time a fracture of the body of the bone and one of the ramus without any displacement. The middle fragment may also be separated from the others without being much displaced; such a case was published by Teissier. The patient had received a kick from a horse just at the middle of the chin; there was thus caused a fracture at the symphysis, and another of the right ramus; the middle fragment was carried downward about one line—a displacement too slight to induce any perceptible deformity.†

But when the middle fragment has been completely detached and driven in, it is unsustained by the rest of the bone, and the muscular action draws it backward and downward without hindrance. In a patient whose case is given by Lecat, one of the fractures was on the right, between the last two molars, the other on the left, between the canine and the first bicuspid; the middle fragment therefore comprised the entire chin.‡ *Fig.* 15 shows a case in which a part merely of the chin is separated; one of the fractures is close to the left ramus of the bone; the other, commencing between the two left in-

* *Revue Médicale*, March, 1835.

† *Journal de Médecine*, 1789, tome lxxix, p. 246.

‡ Lecat, *Remarques sur une espèce part. de fract. de la mâchoire inf.*, in the *Supplément aux Instit. Chir. d'Heister*, p. 154.

cisors, passes obliquely downward and to the right; and moreover, what is remarkable, it divides the thickness of the bone in such a way that in its upper half, which is to the left, the obliquity is at the expense of the inner face, and in its lower half, which is to the right, it is at the expense of the outer face. This fragment was drawn considerably downward and backward from the other two, and we shall see hereafter how and why it was that its reduction could not be accomplished. Finally, *Fig.* 16 shows a middle fragment situated entirely outside the chin. As far as I could judge from a careful examination of the specimen, the anterior fracture, separating into two the alveolus of the first incisor on the left side, passed downward obliquely to within more than a centimètre of the median line; the posterior one was situated about between the second bicuspid and first molar teeth of the same side. The injury was caused by a charge of small shot fired from a gun, and several grains of the shot were still imbedded in the callus. The middle fragment had been forced downward and backward, but also so turned that its lower border looked forward and to the left, and its anterior face almost directly upward; the two others, riding up over it, were brought toward one another a good deal in front, and the interval still remaining between them had been filled up by a sort of fibrous ligament. The callus had formed in this position, and therefore with a deformity of which the drawing cannot give any adequate idea.

Is this turning over inward of the middle fragment owing to its entirely lateral position, or was it overlooked in the preceding observations? I cannot say. We should notice also that the depression seemed much more marked on one side of the chin than on the other, and see if further observations will enable us to generalise this phenomenon in fractures of this kind.

The swelling is rarely considerable, and is usually limited to the point struck. Salivation hardly ever occurs except in case of considerable displacement, but may then be present to a very marked degree; one of M. Neucourt's cases filled two spittoons daily. Loosening of the teeth is also much less common than we should be led to suppose; in order to their being either loosened or forced out, the blow must impinge directly upon them. But an accident which deserves more extended notice is injury of the dental nerve.

It would appear at first as if no fracture could occur between the foramina of entry and of exit of this nerve, without more or less damage to it, nor any displacement of the fragments without tearing it. No one, however, had pointed out any symptom connected with it till J. L. Petit mentioned, among the signs of fracture of the jaw, *very severe pain, singing in the ears, numbness of the cheek, spasmodic movements of the lips*, all which, according to the theory of those times, were ascribed to lesion of the inferior dental nerve. Rossi has extended this list; he asserts that injury of the nerve

leads to convulsive spasms, from which he has seen the most *annoying and incurable results;* and he therefore proposes separating the fragments if necessary, and cutting the nerve through with a narrow bistoury. Flajani relates also the case of a patient who, on the fourth day of a fracture of the jaw, was seized with fever and subsultus tendinum; by the fifth day there was delirium, with muscular contractions over the whole body; and death ensued on the ninth. At the autopsy, the dental nerve was found torn, and nothing abnormal within the skull. It is, however, very evident that these symptoms are those of cerebritis; and in Flajani's case especially, the blow was so severe that the man lay for some time insensible.*

Boyer has avoided this mistake, and shows things under a truer aspect. "Although I have seen," says he, "a large number of fractures of the jaw, both simple and compound, and even from gunshot, I have never seen such symptoms. Once only I have observed in a student of surgery, who had his jaw broken in two places with severe contusion of the soft parts, a paralysis of the depressor anguli oris and depressor labii inferioris, causing slight drawing of the mouth; this I ascribed to the tearing of the inferior dental nerve." M. A. Bérard saw complete loss of sensibility in the corresponding lip in a patient with a vertical fracture, without displacement, between the second and third molars; it extended from the mouth to the chin, and from the labial commissure to the median line; this paralysis lasted only a few days.†

Some idea of the rarity of such symptoms may be formed from the fact that I have been able to find no other cases recorded, and that I myself have never seen them. Doubtless so slight a paralysis of the lip would sometimes pass unnoticed among graver symptoms. Thus in the case before quoted, Flajani did not observe it; and in the fracture represented in *Fig.* 16, the nerve had certainly been ruptured, for on introducing a bit of whalebone into the dental canal in the posterior fragment, this canal was found open for a distance of some millimètres from the fracture. But in many cases, the nerve is protected from any stretching by the overlapping itself, and from any pressure by the separation of the fragments and by the space between the two tables of the bone. *Fig.* 14 affords a striking example of this; I have already said that the fracture in that case was owing to a fall from the second story; here the shock must assuredly have been very violent. The overlapping was also quite notable; still the nerve may be seen to be perfectly intact, by means of a notch which I made in the posterior fragment, and I may add that it was not compressed at any point in its whole extent.

But although fracture of the jaw is rarely accompanied by symptoms

* Rossi, *Médecine Opératoire*, tome i, p. 78; Flajani, *Collezione d'Osservazioni*, etc., Roma, 1802, tome iii, p. 166.

† *Gazette des Hôpitaux*, Aug. 10, 1841.

arising from this source, it sometimes presents much graver complications from the severity of the external violence. I do not allude to the presence of a wound, which is less serious here than in other parts of the body. Monteggia has seen a fall on the chin produce hemorrhage from both ears, without any fracture; such a phenomenon may occur as a complication of a fracture; thus Teissier's patient lost a good deal of blood in this way. The brain sustains more or less concussion, and this important complication explains the exceptional mortality of these fractures. Alix relates the case of a young man aged 20, who broke his jaw by falling from his own height upon his chin. He lost his consciousness; on the third day he was restless and feverish, on the fourth he had convulsive movements, and on the sixth he died.* In this category come properly the cases seen by Rossi and Flajani, mentioned above; and lastly I may add, that of the twenty-seven instances treated at the Hôtel-Dieu, there were no less than four deaths.

Aside from this complication, which is distinct from the mere fracture, the latter is a very simple affair, and will do very well if properly treated. The callus may even be formed without any aid from art; Boyer saw consolidation occur, but not without deformity, in a water-carrier who would not endure any dressing, nor abstain from either speaking or chewing when the pain did not prevent him. M. A. Bérard relates the still more singular case of a child whose fracture made no progress toward recovery till the apparatus, an ordinary bandage, was removed.† But we must not rely too much on such cases as these; this fracture, like all others, requires rest in order to unite, and non-union of it has more than once occurred. Boyer, who has seen several instances of this, says that it offers very little hindrance in mastication; but the following case, related by M. Horeau, shows however that it is not always so.

A colonel received a gunshot wound which broke the right lateral portion of the body of the bone, some lines from its junction with the ramus. A large number of splinters were extracted, and cicatrisation was at last obtained; but there remained a false joint seated between the first and second molar teeth. In the ordinary condition of things, these two teeth were on the same level, and they were not even deranged by pushing the fragments from before backward or from behind forward. But if the posterior fragment were raised and the anterior depressed, the second molar tooth was several lines above the level of the first. The result was great difficulty in chewing on this side; consequently the food was habitually carried to the left molar teeth, and its trituration was neither easy or complete. The digestion was impaired, and although enjoying good health, the colonel could not take more than his habitual quantity of food with-

* Alix, *Observata Chir.*, fascic. i, obs. 10.
† *Dict. de Medécine* en 30 vol., art. *Mâchoire.*

out being made uncomfortable; and the pains thus caused sometimes became very violent.*

It must be stated also that consolidation may be delayed by other causes. M. Neucourt quotes a case in which an abscess was developed at the seat of a simple fracture without displacement; it was opened from without, but the pus made its way into the mouth also. Monteggia saw, after a fracture from a blow with a stick, inflammation and suppuration of the entire periosteum, and hence complete necrosis resulting in death.

This diagnosis, when there is any displacement, cannot be difficult. When there is no displacement, we must try whether pressure does not cause pain at some particular part of the bone, and having ascertained this we must seek to produce crepitation by working the fragments in different directions. We must also make the patient open and close his jaws strongly, to see if either of these motions causes a sensible separation at any part of the alveolar arch; lastly, we may as a *dernier ressort* press on the two angles of the bone as though to force them together; this manœuvre will almost certainly induce severe pain at the seat of fracture, and separation of the fragments.

The prognosis, when the fracture is simple and without displacement, hardly concerns anything but the duration of the treatment. Boyer makes it forty days, which is a little over-estimated; thirty days will commonly suffice; still, however well consolidation may go on, it is better to wait some days, remembering that mastication requires great solidity in the jaw. When there is considerable displacement, the prognosis should be materially influenced by the degree of difficulty met with in reducing the fragments and keeping them in place.

The reduction is generally easy. In fact, whether there are two or three fragments, one can always grasp them with the fingers, the lower edge of the bone being just under the skin, and the upper affording a still more direct hold by means of the dental arch. I have seen but one case in which the difficulties of reduction were great; but it must at the same time be confessed that they were then invincible.

This case was the one before mentioned, of double fracture; it is represented in *Fig.* 15. The patient was admitted into the wards during M. Velpeau's service, and I came on duty a few days afterwards. The middle fragment, which was strongly drawn downward and backward, was easily brought forward nearly to a level with the other two; but when it came close to that on the right side, it seemed to catch against its posterior face, as is seen in the figure, and no effort could disengage it. The resident physicians had failed, and so

* *Journal de Médecine*, by Corvisart, etc., tome x, p. 195.

did I. M. Velpeau, returning two days afterwards, was not any more successful. Finally the patient died, and the autopsy showed the source of the difficulty. The right fragment, in its upper half, was bevelled at the expense of the external face; the middle one, at the part corresponding, at the expense of its internal face. A very severe blow, and even a double fracture, must have been sustained to drive this piece backward in such a way; and if we could have brought it forward, it could easily have been kept in place by the support given it by the fragment on the right side. But this bevelled edge, now placed in front of it, opposed an almost insurmountable obstacle to its disengagement; there was an overlapping of the edges of which one would have no idea; and even after death we found that to effect the reduction it was necessary to draw the middle portion downward and forward, so as to carry it first below and then in front of the other.

To maintain reduction, numerous means have been devised, all however coming under four heads: (1) *bandages;* (2) *fastening the teeth together;* (3) *double pressure*, exerted at the same time on the dental arch and on the base of the jaw; (4) *ligature of the fragments.*

(1.) Most *bandages*, from the two straps of Hippocrates to the single or double *chevestre*, have the same mode of action as the *fronde*, which has the advantage of greater simplicity and solidity.

The *fronde*, [a bandage with four tails, the body of which being applied to the chin, one pair of the tails is fastened at the top of the forehead, and the other pair around the occiput,] invented by Soranus, and approved by J. L. Petit and by Boyer, acts in the first place by fixing the lower jaw against the upper, and secondly by pressing the fragments together, when they are once brought in perfect contact. It fulfils all the indications extremely well when there is no displacement; but it has the inconvenience of keeping the mouth hermetically closed during the entire treatment, and for this very reason causing a slight gaping of fractures situated in front; of this M. Neucourt gives an instance. It has seemed to me that so much rigor was unnecessary, and that, provided the patient abstains from extended motions of the jaw, it would suffice to press the fragments together antero-posteriorly to keep them suitably at rest. I therefore content myself with applying over the chin and sides of the jaw a large strip of lead-plaster, making one turn and a half with it around the head, and directing the patient to speak as little as possible, especially during the first few days.

Another useful precaution is to make the patient keep his bed, resting his head always on the occiput. M. Neucourt has observed that when the head is turned on the pillow, either to the right or to the left, a movement at the seat of fracture is made known to the patient by crepitation, even with dressings much firmer than the *fronde.*

The rule is doubtless much more important in fractures accompanied with displacement; any inclination of the head rarely failing to reproduce this, while the deformity almost always disappears when the head is restored to the straight position.

M. Bouisson has proposed a *fronde* of elastic webbing, so as to allow the jaw to be slightly depressed;* this bandage, which has not yet been tested, would perhaps be found useful in some cases, although it certainly affords less solidity than the ordinary one. This solidity others have attempted to increase; we find in Theodoric the germ of an idea subsequently brought forward by Bœttcher, which consists in placing a small pad on the outside of the jaw, as an external splint, and another below and within, to act as an internal splint.

Theodoric added to these others, dipped in white of egg, and supported the whole by a leather cap. But it will be seen that the pretended internal splint can never be anything but an inferior splint, and cannot serve to sustain the outer one. Perhaps the pads, placed on the sides of the jaw and held there by the *fronde*, may exert a somewhat greater force in separating the fragments; besides this the apparatus has no other effect than the ordinary four-tailed bandage.

(2.) *Fastening the teeth together* dates back to the time of Hippocrates; it has ever since then been done by means of the ligature. With a gold wire or flaxen thread passed round below the crowns of the teeth nearest the fracture, these were firmly bound together, so as to keep them in contact and on the same level. This is a much more effectual means than the *fronde*, and capable of overcoming certain displacements which are somewhat obstinate. I have mentioned it as successfully used by Alix and Ledran for fracture of the upper alveolar arch; and also in Ledran's patient for a concomitant fracture of the lower jaw. Other facts which I have collected, however, forbid our placing much confidence in it in the cases under consideration. Bush resorted to it in a fracture just at the symphysis, using the *fronde* also. Next day the wire had come off, and the displacement was as marked as before. M. A. Bérard relates a more serious case; he had used a silver wire, well annealed, which was passed twice round the necks of the teeth adjacent to the fracture on each side. The approximation was perfect and the immobility complete, for some days; but before long the gums swelled, and grew painful; the teeth were loosened, and the removal of the wire became necessary. M. Chassaignac thought to avoid these evils by embracing with the thread four instead of two teeth on each side, and by putting it half-way up the crown, so as to remove it from the gum and prevent irritation. The case related in support of these ideas is entirely conclusive. On the seventh day of a simple frac-

* *Annales de la Chirurgie*, tome viii, p. 472.

ture, the surgeon bound the teeth together with waxed hempen threads; these threads were found broken on the next day. Another attempt was made with silk threads, and at the end of three days they were broken or displaced; the trial was now abandoned. On the eighteenth day it was resumed with a gold wire; on the fourteenth day afterwards the wire still held, but the gums were red and bleeding. The patient not having returned again, the subsequent history of the case is unknown.*

On the whole, while useful only in cases of slight displacement, ligation of the teeth involves disadvantages preventing us from resorting to it except with great caution. Moreover, the teeth are sometimes set so close together as to render it impossible, as in a case cited by Bertrandi; and it should not be thought of when the teeth are worn, carious, or wanting in the vicinity of the fracture.

Guillaume de Salicet advises us to fasten together with a silk thread not only the teeth belonging to the two fragments, but with them also the corresponding ones of the upper jaw. This plan, more secure but at the same time more difficult than the other, would suit only such fractures as were farthest from the body of the bone, seeing that in front the teeth do not correspond in the two jaws.

[In the United States the treatment for fracture of the lower jaw consists almost exclusively of bandages, the teeth being wired together if the displacement tends to recur. The bandage most in use is that of Dr. John Rhea Barton, forming three ovals, one round the occiput, one round the face, and one round the base of the head and chin; it begins at the occiput, is carried thence round the side of the head, and up over the sagittal suture to the opposite temple,—thence under the chin, up over the sagittal suture, and back again to the occiput,—thence around the front of the chin directly back to the starting-point. This is applied very firmly, and no more motion is allowed to the jaw than is absolutely unavoidable. We often make use also of a splint of pasteboard or gutta-percha, moulded to the exact shape of the jaw, as an aid to the bandage. The results from this mode of practice are very satisfactory, although in exceptional cases some surgeons tax their ingenuity for contrivances such as are mentioned in the ensuing paragraphs.]

Lastly, in a case of non-consolidated fracture on the right side, with loss of substance, overlapping, and displacement upward and outward of the posterior fragment, the dentist Lemaire was called in by Dupuytren, and devised two other plans for ligation; first, to carry the posterior fragment inward, he united by means of a platina wire the wisdom-tooth in this fragment to one of the bicuspids of the other side; then to carry the anterior fragment forward and lessen

* Bush, *London Med. and Phys. Journal*, Nov., 1822, p. 401; A. Bérard, *loc. cit.*; Neucourt, *loc cit.*

the overlapping as much as possible, a second wire was stretched from the first lower bicuspid on the right side to the first upper bicuspid on the left; and a third bound together the two canine teeth on the left side. This third wire is only an application of Guillaume de Salicet's method; but the two others, passing from one side to the other not only of one but of both jaws, constitute two really new resources. We may indeed derive hence a valuable idea; although the wires were left in place for over two months, it is not said that the teeth suffered from them; only the one which passed transversely from one fragment to the other had cut through more than half the thickness of the tongue; and as the layers first divided had united again as the wire went deeper, the latter became inclosed like a seton; it had to be cut on each side and drawn out like a hare-lip pin.*

On the whole the ligature, however applied, is liable to some notable inconveniences. I endeavored to attain the same end in a simpler and surer way by embracing the teeth of both fragments in a trough, fixing them by means of pressure with screws. My apparatus consisted of a thin and flexible sheet of iron, capable of adapting itself to all the varieties of curvature of the posterior aspect of the dental arch. From its two extremities, and from two intermediate points, rose four small steel branches, which were bent twice at a right angle, so as to come parallel to the anterior face. This sort of open trough thus embraced the dental arch in four points; and there being a screw at the end of each stem, the teeth could be fastened at those four points against the iron piece, as against a posterior splint. The enamel was protected by means of a bit of lead to receive the end of the screw.

M. Nicole de Neubourg had already conceived an analogous idea; having to treat a fracture seated between the second incisor and the canine on the right side, he had two little curved steel plates made, fitting to the anterior and posterior faces of the teeth; a small steel mortise embracing both the teeth and the plates, served somewhat to keep them in place, and by means of a screw prevented their slipping. I have seen this instrument at M. Charrière's; I do not know what its success has been, but I doubt whether it was complete. Besides, from the permanent curvature of the steel plates, it could fit but one mouth, and but one portion of the dental arch.

These two apparatuses, like the ligature of Hippocrates, are intended to fix the teeth without interfering with the movements of the jaw; there are others which imitate those of Guillaume de Salicet and of Lemaire, keeping the jaw immovable in order better to insure the fixation of the teeth. Muys has given a description of an instrument devised by an unknown German surgeon, for a fracture with

* *Journal Univ. des Soc. Médicales*, tome xix, p.77.

displacement of one fragment inward and of the other outward. It was a sort of ivory trough, receiving into its cavity four teeth, two of each fragment; the patient was only twelve years old, and consolidation was effected in twenty days.* Boyer recommends an analogous apparatus, consisting of a plate of cork hollowed on its upper and lower faces so as to receive at once the teeth of the upper and lower jaws.

These instruments are all of very limited application. For those which work by screws, we must have to deal with full sets of teeth, the crowns of which must be sufficiently elevated above the gums. As to simple troughs, in the first place, inconvenience arises from the presence of a somewhat voluminous foreign body in the mouth; secondly, the nature of this body, it being susceptible, cork especially, of becoming loaded with mucus, and liable by the end of the treatment to give out a most fetid odor; thirdly, a last but not less serious annoyance results from the forced closure of the mouth; the use of a four-tailed bandage or of some equivalent application is in fact essential to the efficacy of these instruments.

(3.) The third method, the credit of which has been given to Germany, had been pointed out in 1780 by Chopart and Desault, to whom must be restored their incontestable priority.† When the fracture occupied both sides, they proposed to keep the fragments in place *by means of dressings composed of braces of iron or steel, placed upon the teeth, on the alveolar border, covered with cork or with plates of lead, and tightened up by screws to a plate of sheet-iron or to other* points d'appui *fixed underneath the jaw.* In other words they sought to fix the bone by two splints, one inferior, under the edge of the jaw, the other superior, applied over the teeth, the two being held together by an intermediate branch. In 1799, a German surgeon, Rutenick, applied such an apparatus successfully; Bush, in England, devised another in 1822; M. Houzelot made his in France, in 1826; other modifications bear the names of Kluge, Jousset, Lonsdale, etc. Wood, iron wire, steel, and tin, have been successively used.

I once employed Bush's apparatus, modified as follows: a steel branch is bent below at a right angle, so as to go under the chin, and above, so as to pass into the mouth; here it describes two curves, one around the lower lip so as not to press upon it, the other so as to apply itself to the dental arch. Its lower extremity is bored for a screw, this screw supporting a metal plate properly padded and fitting either to the chin or to any other part of the base of the jaw, according to circumstances. The fracture being now reduced, we apply over the adjoining teeth of both fragments a small mould of lead or silver,

* Muys, *Praxis Rationalis*, decad. xii, obs. 3.

† It is even likely that this idea belongs exclusively to Chopart, Desault having never again spoken of it.

on which the upper part of the steel branch may press; the padded plate is arranged beneath the jaw, and the screw, turned by a key, forces this plate against the base of the bone until sufficient pressure is obtained.

In the contrivance of M. Houzelot, the connection of the two splints is made by a different mechanism. The stem does not curve back under the chin, but descends vertically, presenting in its two lower thirds a longitudinal fenestra; the sub-maxillary plate has at its anterior part a narrow square branch which plays in this fenestra, and which carries at its end a screw, so that it may be fixed at any required height.

These apparatuses, and others made on the same principle, can be used only in fractures at the anterior part of the jaw. That of Rutenick, modified by Kluge, has some spare stems for fractures seated far back, which make a bend in the mouth after passing the lower lip, skirt along the dental arch till they reach the seat of fracture, and then at last curve so as to press on the mould and on the teeth.

After all, firmly as these instruments may be put on, they all tend to slide forward on the chin; hence they must be confined by cords or bands going around the neck, and even, if need be, tied over the head like the four-tailed bandage, leaving, however, enough play to the jaw for it to be opened at will.

Here, indeed, is the great advantage of this plan. While fixing the fragments more solidly than any other, it still permits the patient to talk, to take semi-solid food, even to chew the soft part of a piece of bread. But it also frequently entails some considerable inconveniences; and it is above all important for us to know what are its effects on the living subject.

Rutenick invented his instrument for a lady in whom the displacement had resisted all other means; and he was completely successful. M. Jousset likewise obtained good results in two cases; his second patient having got the habit, from wearing the instrument on the left side, of talking with the right side of the mouth, kept the mouth thus twisted for about fifteen days after the apparatus was removed; this, however, was of no importance. M. Houzelot has published three observations of fractures treated with this contrivance. In the first, it was kept on for thirteen days, when an epileptic paroxysm deranged everything, and the patient, furiously delirious, was transferred to Bicêtre. The second patient complained soon after its application of a very severe pain at the lower edge of the jaw; there was copious salivation; by the sixth day these symptoms subsided, and on the tenth the apparatus was removed; after which the fragments showed no tendency to displacement. It is not stated why the instrument was taken off so early; probably it was because of the inflammation excited by it underneath the jaw; in fact there was an abscess formed there, which was opened seven days after-

wards. In the third case, the apparatus was kept on for thirty days; here also it gave rise to an abscess at the point where the plate pressed on the jaw.

We find also, in one of M. Neucourt's cases, that this apparatus was applied for a double fracture, with notable displacement of the middle portion; the reduction was well kept up, but the apparatus had to be taken off on the seventeenth day, an abscess having formed beneath the chin.

At all events, however, the instrument has been endured for a longer or shorter time, and always with some good results. Some patients seem more sensitive, whether from the edge of the bone being sharper, or from the skin covering it being thinner. For some reason or other, the patient for whom Bush had his instrument made was unwilling to wear it for more than a few days. Rutenick's apparatus was not endurable for any greater length of time in a double fracture in a young man of twenty.* I myself tried Bush's apparatus on an epileptic at Bicêtre, for a simple fracture with very slight displacement, and the pain was so great that I had to take it off. I had at first thought these symptoms due in some degree to the too early application of the instrument; but in my patient I waited scrupulously till all inflammation had subsided, and in M. Houzelot's second patient the apparatus, though not put on till the sixth day, nevertheless gave rise to abscess.

There is therefore a radical defect in these contrivances, which is that they exert too direct a pressure upon a sharp bony ridge. Perhaps it may be required, in order to protect the integuments from all pressure, to pass steel points through them, as I have had to do for fractures of the leg. It would be necessary to act upon each fragment with two points, separated by two or three millimètres, so as to catch the bone and prevent its slipping; such points could be easily adapted to the sub-maxillary plate of Bush or of M. Houzelot.

I must not omit to notice a very singular fact regarding one of the cases whose history is related by M. Houzelot. After the apparatus had been kept on for thirty days, the teeth of the upper jaw corresponding to the plate were below the level of their neighbors by about a millimètre; but ten days afterwards they were on the same level. It is very singular that this effect should have occurred in the upper jaw only; and no other instance of it has been observed.

(4.) The *ligature of the fragments* has been employed but once, by M. Baudens, in the following case. A chasseur, by a fall from a horse, broke his jaw at the second molar tooth on the left side; the fracture was complicated by a wound and by splinters, and was oblique downward and forward; the posterior fragment, strongly drawn

* Michaëlis, *Beschreibung*, etc.; *Journal de Chirurgie*, by Graëfe and Walther, 1823.

inward, lost its place as soon as it ceased to be held. M. Baudens passed a ligature round the fragments, and sutured the wound. No bad symptom ensued, and the ligature was withdrawn on the twenty-third day, leaving the bone regularly and completely united. This certainly is an extreme resource, and should not be employed except in case of necessity; but in oblique fractures at least its efficacy is beyond doubt, and this first trial answers all the objections which would not fail to spring up in theory.

The process is, besides, very simple. M. Baudens used a needle eight centimètres in length, flexible in the middle, so as to take any required curvature, and pierced with two eyes, one near the point, the other close to the head; the ligature, formed of six or eight ordinary threads, was passed through both eyes at once. The fracture being reduced and so maintained with the left thumb and forefinger, the operator passed the needle under the lower edge of the jaw, following the inner face of the bone, and bringing out the point between the gum and the neck of the tooth, so as to be able to draw out by the mouth the end of the thread engaged in the eye near the point. The needle being now withdrawn by the same track, was directed along the external face of the bone, emerging in the same way by the side of the gum, and this time withdrawn through the mouth; so that the loop of the ligature surrounded the base of the jaw, and the two ends could be tied in a double knot above the teeth. A needle having one eye near its point would accomplish the end as well, and would not even need to be withdrawn through the mouth, which would be the most difficult part of the operation in a fracture seated somewhat far back.

Such are the plans hitherto proposed; some useful only in the simplest cases, others multiplying our resources in proportion to our difficulties. Certain circumstances sometimes prevent their employment. If the teeth are wanting in the vicinity of the fracture, we may, if necessary, contrive some artificial substitute for them.

Duverney has suggested that the jaw might be broken when completely destitute of teeth. This case seems never yet to have presented itself; but if none of the methods mentioned could be used, the suture of the fragments would be our only resource.

When a tooth has been loosened or displaced by a fracture, what is to be done with it? Mr. B. Bell advises its extraction; Heister and Duverney prefer making an attempt at its preservation. This would certainly be safest; there will always be time enough to extract if circumstances demand it.

I know of but two cases in which art has interfered to procure consolidation of ununited fractures of the jaw. Physick succeeded by passing a seton between the fragments; I have not been able to

procure any further details of the case.* Dupuytren resected one of the fragments and rasped the other; but he had to encounter very great difficulties in keeping them in contact; and it was for this very case that Lemaire devised the triple ligature before described. The patient is said to have been completely cured, but at the expense of long-continued and cruel suffering. The suture of the fragments would have so simplified the matter, that in a similar case I would not resort to any other method. It would be the same also in recent gunshot fractures, with destruction of the soft parts and obstinate displacement of the fragments; for instance, no one can examine *Fig.* 16 without being convinced that the suture would have been the only and at the same time the all-sufficient means of producing coaptation.

§ II.—*Fractures of the Neck of the Jaw-Bone.*

This fracture is excessively rare, and for my own part I have never seen it. It appears to have been observed by Soranus, after which no more mention of it occurs until the time of Desault, and I know at present of but eight published instances.

The cause ascribed in both of Desault's cases was a fall on the chin. In a patient treated by Ribes, the blow seemed to have fallen on the corresponding side of the jaw, part of the lower lip and of the cheek having been at the same time divided; and in another case, reported by M. A. Bérard, the patient had fallen from a height of twenty-five feet, fracturing the malar bone and the petrous portion of the temporal on the right side, along with the neck of the corresponding maxillary condyle, the blow having likewise fallen on this side.† Here, then, are at once two well-established orders of causes.

[A man was brought to the Pennsylvania Hospital in the fall of 1855, who had been injured by the premature explosion of a blast;

* [The case was published in the *Philadelphia Journal of the Med. and Phys. Sciences*, vol. v, p. 116; being reported by the patient. The lower jaw was broken (it is not stated in what way) on the 29th of March, 1820. The fracture was double,—transverse on the right side and oblique on the left. Reduction of the fragments on the left side was very difficult, and its maintenance still more so. An improperly applied compress subsequently bore the anterior fragment too much inward. A false joint ensued, with injury to digestion, barometric pains, etc. In November, 1820, Dr. Physick was applied to, and removed the neighboring teeth, with some little relief. Being again consulted on the 27th of April, 1822, he passed a seton, which induced suppuration and a discharge of bits of necrosed bone. July 27, the seton was removed, and at the time of the report the jaw was almost entirely healed.]

† *Mem. sur la fracture des condyles de la mâchoire; Ouvres chir. de Desault*, tome i, p. 47; Ribes, *Diss. sur l'articulation de la mâchoire inférieure*, Thèse inaug., Paris, an xi, [A.D. 1803;] A. Bérard, *Gaz. des Hôpitaux*, Aug. 19, 1841.

among other injuries, which proved fatal, he had a fracture of the neck of the right condyle, diagnosed during life, and verified by the *post-mortem* examination.]

It seems also that to each of these causes there corresponds a different lesion. In the two cases from falls on the chin, the fracture of the neck was simple and uncomplicated; after a blow received on the side of the jaw, the fracture of the neck was accompanied by one of the body of the bone, on the opposite side.

M. Houzelot has quoted a case yet more complicated, where, in consequence of a fall from a height, there were found fractures of both condyles, of both coronoid processes, and of the symphysis.

There remain two instances given by Ribes, and another by Bichat, in which the cause is not stated; two were simply fractures of the neck; the other a fracture at once of the neck and body, so that these two forms would seem equally frequent.

Desault, or rather his pupil Bichat, notes as symptoms of this fracture, when simple, pain, difficulty of movement, crepitation; inequality, sometimes perceptible, in the region of the fractured condyle; the facility of burying it in the zygomatic fossa by pushing it forward; its not sharing in passive motion of the rest of the jaw; and lastly, an almost constant displacement, the condyle being carried forward and upward, the body of the bone remaining behind, and the two fragments being separated by an interspace more or less perceptible. The two cases reported by him do not afford the details necessary in order to appreciate the value of this description; we learn only that in one case there was preternatural mobility at the seat of the fracture, and in the other an almost entire inability to move the jaw.

We must here distinguish between cases in which the fragments remain impacted, without displacement, or with a partial and very slight displacement, and those in which they become quite loosened from each other. In the first case, there is indeed pain, crepitation, and some little deformity, but no notable mobility between the fragments; in the second case, crepitation is apt to be wanting by reason of the displacement, and the body of the bone, separated from its condyle, presents at the seat of fracture an abnormal mobility.

This mobility was observed by Soranus, who even makes it a means of diagnosis between fracture and luxation: *Fractura quæ fit ad rostra maxilles raphani modo, dignoscitur quod moveatur dum ope digitorum adducitur; luxata vero immobilis sit usque ad sejunctionem.*

There is in fact, when the fragments are separated, a phenomenon, omitted by Bichat, but pointed out by Ribes, which might lead to a suspicion of luxation of one of the condyles, viz., that the chin is drawn to one side. But in luxation, it is carried to the side opposite the lesion, while in fracture it deviates to the same side. This

is because the corresponding half of the bone does not merely *rest* posteriorly, but is drawn at once backward and upward by the unopposed action of the muscles.

The displacement of the condyle, induced by the cause of the fracture, increased and maintained by the action of the external pterygoid muscle, is a main point in the history of this fracture. The condyle itself remains in relation with the glenoid cavity, but the pterygoid muscle makes it execute a movement of rotation, carrying the fractured neck upward, forward and inward, so that the fractured surface of the inferior fragment is in relation only with the posterior surface of the neck and of the condyle.

When the fracture is double, the fragments may remain in contact, just as when it is single; or they may undergo the same displacement as occurred in the two patients of Ribes; or the middle fragment by itself may be carried inward, as was seen by M. A. Bérard. In his patient, the double fracture had not at first involved any notable displacement; but on the fifth day there came on a convulsive trembling, which led to a very considerable displacement inward of the middle fragment; death took place two days afterwards.

The diagnosis is generally easily deduced from the symptoms pointed out; we can, moreover, explore the fracture at once externally and internally, by passing a finger into the mouth.

Simple fracture, without displacement, may unite without any apparatus; it is proper, however, to keep the jaw at rest by means of a *fronde*. Bichat cites a case in which, motion having been inconsiderately impressed on the bone, the ununited condyle exfoliated, and was partially thrown off. Consolidation, when favored by rest, is quite prompt; in both of Desault's cases it was completed by the thirtieth day.

But when the two fragments are separated, the treatment is much less easy. "A surgeon in Paris," says Ribes, "was called to a student of surgery who had a fracture of the body of the jaw-bone and another of the neck of the condyle; in spite of the most assiduous and skilful attendance, the patient recovered with the chin drawn to the same side as that of the fractured condyle."

Ribes himself had to treat, in the year II, [of the French Republic; A.D. 1794,] a patient with a similar fracture on the left side; and in spite of all his care in applying the means then in use, the result was the same as in the foregoing case, the chin being twisted toward the fracture.

The means proposed for reduction arrange themselves, so to speak, under two methods. The first, pointed out by Chopart and Desault, consists essentially in carrying forward the body of the bone; some would at the same time raise the chin; and different bandages have been devised thus to fix the jaw. Such were the means at first tried

by Ribes, which so sadly disappointed him. Bichat relates, however, two cases thus treated by Desault with complete success, except that the movements were not perfectly restored. If, indeed, the cure was complete, there cannot have been disjunction of the fragments, and therefore the manipulations and the bandage employed by Desault were perfectly useless. As is justly remarked by Ribes, there was nothing in it all which could change the position of the condyle, drawn inward by the muscle attached to it.

Thus, then, the true indication, which constitutes the second and the only rational method, is to act at once on both fragments, but particularly on the condyle, to bring them back to their proper relation. In order to do this, if the fracture is on the right side, the anterior part of the jaw is to be seized with the left hand and drawn horizontally forward, while the right forefinger is carried to the side and upper part of the pharynx. There we encounter first the prominence of the styloid process; but carrying the finger forward, we soon come to the posterior edge of the ramus of the jaw; and passing along this border from below upward, we come to the inner edge of the condyle, which we push outward so as to engage it against the other fragment. This cannot be done without producing nausea, as is always the case when the finger is carried into the throat; but this inconvenience is but trifling. Reduction being accomplished, the jaw is pressed upward and backward so as to fix the condyle between it and the glenoid cavity; it is then closed, and retained in place by means of a four-tailed bandage.

Ribes, to whom this plan is due, had occasion to apply it in the case of a cannonier who had a fracture of the neck of the right condyle with a wound of the corresponding cheek, and another fracture on the left side of the body of the jaw. The destruction of the soft parts gave him the idea of carrying the finger to the inner side of the condyle in order to replace it, which he did easily; and the patient recovered without deformity at that portion of the bone.

CHAPTER IV.

FRACTURES OF THE HYOID BONE, Etc.

These fractures are extremely rare, and have only latterly attracted attention. The close proximity of the hyoid bone and larynx, as well as their arched form, expose them to the same causes of fracture; thus a hand tightly grasping the throat, or a similar force applied by a cord, as in hanging, might under some circumstances fracture the hyoid bone or the thyroid cartilage.

§ I.—*Fractures of the Hyoid Bone.*

Notwithstanding the considerable number of subjects carefully examined after death by hanging, we know of but two or three cases in which the hyoid bone was broken by the cord; and there has been also much difference as to the interpretation of the facts. M. Orfila relates the case of a locksmith aged 62, who hung vertically nearly half a foot from the ground, in whom the hyoid bone was found forced strongly backward, and fractured *at the part sustaining the two cornua on the right side;* the greater cornu was therefore very movable, and could be approached close to the one on the other side. Ollivier (d'Angers) thinks that in this case the action of the cord had nothing to do with the fracture, which he ascribes to the sudden and violent throwing back of the head; he adds however that he made an autopsy in another instance, in which, although the disposition of the cord and of the head was the same as in M. Orfila's case, the hyoid bone had remained intact. M. Cazauvieilh met with a fracture of this bone (probably of the body) in a man who had been hanged; in another he saw a fracture of the greater cornu, but he adds nothing concerning the mechanism producing them; in respect to this therefore science is as yet in want of facts.*

Judging from these three cases, hanging acts chiefly upon the body of the bone; it appears on the contrary that pressure on the

* Orfila, *Traité de méd. légale,* third edition, tome ii, p. 423; Ollivier, art. *Hyoïde, Dict.* en 30 vol.; Cazauvieilh, *Du suicide,* etc., 1840, p. 221.

throat by the hand of an antagonist, the thumb on one side and the fingers on the other, tending to force together the two cornua, affects those branches exclusively. MM. Lalesque, Dieffenbach and Auberge have each published such a case; in the first the left cornu was broken, in the last two, the right. Two of the subjects were men of fifty-five and sixty-seven years; the other was a girl of nineteen.*

The hyoid bone is usually so well protected by the jaw, that it easily escapes pressure or blows not given by an expert hand; thus in the only case of this kind which we know of, the lower jaw was broken also. The account is given by M. Marcinkowski. A woman was brought to the hospital, livid, and in a state of suffocation; all that could be ascertained was that she had been thrown against a wall by a coach which had been overturned upon her. She died in twenty-four hours, and the autopsy revealed a fracture of the left cornu of the hyoid, the jaw also being broken on that side.†

But another much more curious cause of fracture of the hyoid is muscular action, which seems placed beyond doubt by the observation of Ollivier d'Angers. A woman aged 56 made a false step and fell, her head being thrown forcibly backward. At the same moment she heard a very distinct crack at the upper part of the left side of the neck; there was a fracture of the greater cornu of the hyoid.

[Dr. F. H. Hamilton of Buffalo refers, in an article on fractures of the hyoid bone published in the *Buffalo Medical Journal* for August, 1857, to a case reported by Gründer in *Schmidt's Jahrbuch*, volume 68, in which the cause ascribed was muscular violence. He also quotes another, reported by Dr. Wood of Cincinnati, in which the injury was produced by a direct blow, received in falling down stairs. In the former case the result was fatal; the latter did well.]

The symptoms are quite characteristic. This crack as the bone yields seems to be commonly heard, for it was spoken of by three of the patients above mentioned; the pain is severe, comes on immediately, and is quickly followed by very notable external swelling; there is usually also slight ecchymosis. All movements affecting the bone increase the pain, especially those of the tongue, and more particularly attempts to speak or to swallow. One female patient compared the pain induced by swallowing to that from a fish-bone stuck in the throat. In M. Lalesque's patient, the fracture being in the left greater cornu, the tongue seemed drawn to the right; in the young girl treated by M. Dieffenbach, the voice was hoarse, and remained so for a pretty long time; but these were purely accidental phenomena.

* Lalesque, *Journ. Hebdomadaire*, March, 1833; Dieffenbach, *Gazette Médicale*, 1834, p. 187; Auberge, *Revue Médicale*, July, 1835.

† *Gazette Médicale*, 1833, p. 354.

To these symptoms are added, in some cases, crepitation, displacement, and a sensation as of splinters. Crepitation is not heard when the fragments are loose. Thus in M. Dieffenbach's case, slight pressure over the greater cornu pushed both the fragments inward, causing evident crepitation; but as soon as the pressure was removed, the fragments resumed their place. On the contrary, in the two cases of MM. Lalesque and Auberge, the posterior fragment being separated and thrown backward and inward, no crepitation was felt; but the projection of the anterior fragment was easily perceived by the touch, and behind this projection a depression in which might be traced the displaced fragment; lastly the finger, carried far back along the floor of the mouth on the side of the fracture, encountered at once the projection inward of this fragment; and it is to be noted that both observers say that they felt small splinters which had penetrated the mucous membrane. These splinters appear to me to have been merely the sharp end of the posterior fragment. Doubtless it was just such a circumstance which give the sensation of a fish-bone to M. Ollivier's patient—a sensation which disappeared when the fragment was pushed outward.

Fracture of the hyoid bone, when properly treated, is not very serious; its gravity depends entirely on the accompanying inflammation, unless this be carefully subdued. In Ollivier's patient, the inflammation was followed by suppuration, and finally by necrosis of the posterior fragment, which was discharged after three months by the fistula remaining from the abscess. This fistula afterwards closed readily; but there was left a hindrance to deglutition amounting sometimes to pain, and persisting for several years.

The treatment should therefore essentially and promptly combat this inflammation, not sparing if necessary both general and local bleeding. But the surest antiphlogistic is the repose of the parts; whence the propriety in these cases of imposing silence, of limiting or absolutely preventing the movement of deglutition, and lastly of reducing and confining the fragments.

When there is no displacement, there is doubtless no need of so much rigor. In his patient, Dieffenbach merely combated the inflammation by an ordinary tisane, without imposing silence or applying any dressing, and the patient recovered no less readily.

But in case of displacement the indications are more urgent. To perform reduction, the forefinger is introduced into the mouth; the posterior fragment is pushed outward and forward; while the other hand, from without, presses on the rest of the bone to bring them in contact. M. Lalesque obtained coaptation only with great trouble; M. Auberge, on the other hand, says it was easy; both had followed the same method, even to the precaution of putting a very firm linen compress between the teeth. I must say, indeed, that

the observation of the latter so strongly resembles the other both in matter and form, as to leave an unpleasant impression on the mind.

Thus both had the head held slightly inclined backward; both were directed to observe immobility and silence; both used the œsophageal tube. M. Lalesque left the tube in position for twenty days; on the twenty-third the tisane was swallowed without difficulty. On the fortieth, solid food was allowed. On the forty-seventh, the patient talked with ease. On the sixty-fourth day, the cure was complete; the finger, carried into the mouth and over the seat of fracture, detected a slight nodosity marking the reunion. M. Auberge, without entering into these details, says only that consolidation occurred by the end of two months.

Only one question need detain us here: this position of the head, with a view of producing what M. Lalesque very improperly calls *permanent extension*,—is it the most suitable? It may be said that by stretching the muscles and ligaments of the hyoid bone, it fixes it like an object drawn in two directions by stretched cords. But this cannot apply to the case where the head is moderately thrown back; and by carrying it farther back, M. Lalesque himself says that the hyoid is thrown forward, and that there is danger of displacement. I am inclined to believe, for my own part, that a much better means of preventing displacement would be to relax all the muscles; and for this purpose the right posture is with the head inclined forward, or exactly the opposite of the one preferred by M. Lalesque.

§ II.—*Fractures of the Laryngeal Cartilages.*

Almost as rare as those of the hyoid bone, these fractures have been chiefly observed in persons who have died by hanging. Morgagni says he has sometimes seen the larynx thus fractured, and notes that it was always in subjects of advanced years. Remer adds another circumstance; he met with such a fracture in a man who had been hung, in whom the mark of the cord was perceptible over the larynx.

We do not know the precise seat of the fracture in these cases. Other observations would lead us to think that the cricoid cartilage was affected in preference. Such a case was seen by Valsalva; Weiss found this cartilage broken in several pieces, as well as separated from the rest of the trachea; and a third case was observed by M. Cazauvieilh.*

The thyroid cartilage more readily escapes the action of the cord;

* Morgagni, *De sedibus*, etc., Epist. xix, No. 13, 14, and 16; Remer, *Annales d'hygiène*, tome iv, p. 171; Cazauvieilh, *op. cit.*

but it may be fractured by the hand of an antagonist pressing strongly on its two sides. M. Ladoz, in 1838, published an instance of this, observed in a man who had been assassinated; the neck was found compressed by a very thick handkerchief, forming a band about four fingers'-breadths wide; but it presented also lacerations and contusions produced with the hands and nails. The thyroid cartilage presented a fracture with irregular borders, nearly in the form of an S, fifteen millimètres long; it extended from some lines below the upper border of the right half of the cartilage to its lower part, and from the salient angle formed by the right and left halves to the junction of the anterior and middle third of the right half. The person was only thirty-seven years old, but the whole cartilage was in an extremely advanced state of ossification.*

M. Ladoz has no doubt that this fracture was produced exclusively by violence inflicted with the hands and nails. This mechanism is at least placed beyond doubt in the following case, given by M. Marjolin:—

"Two women in the hospital having quarreled, one of them seized the other by the throat, and grasped her so tightly as to fracture the thyroid cartilage from its upper to its lower part. You may conceive that it was not very difficult to detect the fracture, and that there was no apparatus to be applied. Silence, low diet, and a small bleeding, were ordered, and the cure was a perfect one." †

Lastly, Plenck is quoted by Monteggia, as having seen a case of this fracture resulting from a direct blow; the neck, in a fall, striking against the edge of a bucket, both the thyroid and cricoid cartilages were broken.

[Dr. Hamilton (*Buffalo Med. Journ.*, Aug., 1857,) reports a similar case observed by himself, the patient having been kicked by a horse. Dr. H. performed laryngotomy thirty-eight hours after the accident, with relief to the symptoms of suffocation; but the man died in about thirty-four hours, apparently from exhaustion.]

M. Marjolin thinks that the occurrence of this fracture is favored by ossification of the cartilage, an opinion to which the case of M. Ladoz, as well as those of Morgagni, lend a good deal of probability.

Is fracture of the thyroid cartilage in the living subject always so harmless? In Plenck's case, death occurred almost instantly, with convulsions, without the slightest cry, and probably by occlusion of the glottis. In 1823, M. Ollivier communicated to the Académie de Médecine a case in which it was followed by suffocation, at first intermittent and afterwards persistent, till death ensued.‡ It is to be regretted that this case was not published with more copious details.

* *Gazette Médicale*, 1838, p. 698.
† Marjolin, *Cours de Pathologie Chir.*, p. 396.
‡ *Archives Générales de Médecine*, tome ii, p. 307.

CHAPTER V.

FRACTURES OF THE VERTEBRÆ.

Fractures of the vertebræ are very rare; only fourteen cases were treated at the Hôtel-Dieu in the course of eleven years. They occur more frequently in men than in women, and in adults oftener than in other persons; which is explained by a reference to their causes.

These fractures present numerous varieties, first according to the region affected, and again according as they are seated in different portions of a vertebra. We have to study here neither fractures of the atlas and odontoid apophysis, nor those of the articular apophyses of other vertebræ, which we find accompanying luxations. Isolated fractures of the transverse processes are hardly possible except by gunshot, as in one of the men wounded in July, [1830,] who, among other lesions, had had the transverse process of the axis broken by a ball.* There remain fractures of the spinous processes, of the arches, and lastly of the bodies; each of which demand separate study.

§ I.—*Fracture of the Spinous Processes.*

Hippocrates has traced the history of these fractures in a passage too remarkable not to be quoted entire:—

"When one or more of these osseous eminences have been fractured by force, there is at the seat of fracture a deceptive depression, inducing suspicion of a luxation of the vertebræ forward. The patient's attitude also increases our liability to err. For if he tries to bend forward he feels pain, because the skin is stretched at the seat of injury, and the bony fragments pierce the tissues; on the contrary, by bending backward the skin is relaxed, and the fragments cause less irritation. Moreover, if the hand is applied there, the tissues yield forward, and the spot seems empty and flaccid to the touch. This is what especially deceives surgeons. As to the pa-

* *Leçons Orales de Dupuytren*, tome ii, p. 504. An analogous observation may be found in Duverney.

tients, they recover quickly and easily; for all these spongy bones consolidate with rapidity."

Modern writers have added little to this picture. Duverney, however, reports an instance where two of the spinous processes were fractured without any displacement; the fracture was only recognised by their mobility. Aston Key accidentally met in the dead subject with a proof that consolidation is not always so certain as was supposed by Hippocrates. The fracture was in the third dorsal vertrebra; the spinous process was movable, united to the rest by a complete pseudarthrosis, with ligaments, cartilages and synovia.

Sir A. Cooper also has observed some symptoms not mentioned by Hippocrates. A young boy having tried to carry a heavy wheel by passing his head between the spokes, and resting the weight on his shoulders, the load proved too much for his strength, and he fell, doubled up. When brought to Guy's Hospital, he had the appearance of a man long affected with spinal curvature; three or four of the spinous processes were broken, and the muscles detached from them on one side, so that the fragments had an oblique direction. There was no symptom of injury of the cord; the patient recovered without any apparatus, with free use of the trunk and limbs, but still with *deformity*.

This last word refers doubtless merely to the deviation of the spinous processes; it is, however, to be regretted that the account is so scanty that we cannot even learn where the fracture was situated.

I presume that most commonly this fracture is due to a direct cause; a blow, a fall, or pressure. I have seen but two cases of it; in the first, the cause was probably a fall on the back; in the other, the patient had been thrown under the wheel of his cart, which passed over the shoulder and the back of his neck; he died from his other injuries, and the autopsy showed the spinous process of the axis entirely separated by a fracture running downward and forward.

[In a man who died in the Pennsylvania Hospital of injuries received by the fall of a derrick, besides a very extensive comminuted fracture of the left scapula, the spinous processes of the last two cervical and first dorsal vertebræ were found to be broken. These fractures were undetected during his life, (which only lasted four days,) owing to the severity of the other lesions; and were discovered after death by mobility and crepitation being accidentally perceived.]

The symptoms have been sufficiently pointed out; but it is not essential that the muscles should be torn, for the processes to be displaced to the right or left. Paulus Ægineta has indicated the means of diagnosis employed by Duverney, which was by passing the fingers over the fragment to ascertain its displacement and its mobility.

The treatment consists almost entirely in rest. Paulus Ægineta

recommends extracting the fragment by means of an incision. This operation, thus advised in a general way, would be entirely irrational. The spine displaced laterally seems itself to tend to resume its position; Aurran convinced himself of a spontaneous reduction of this kind,* as I myself did in the following case.

An attorney's clerk, aged 22, fell while drunk from a second-story window; he struck first on his heels, breaking both the calcanea, then on his buttocks and loins; he immediately felt an acute pain at the lower part of the back. On examination, following the line of the spinous processes, we found in place of that of the twelfth dorsal vertebra a hollow, very painful on pressure; this spine was displaced to the right, and the swelling preventing its being moved so as to develop crepitation, some of the pupils made just such a mistake as was pointed out by Hippocrates, in supposing that the whole vertebra partook of the displacement, the body of the bone being carried to the left. There was no symptom of injury of the cord; but whenever the patient moved the trunk he felt at the level of the displaced spine such severe pain as to elicit screams; this pain diminished greatly when he was supported by the upper and lower portions of the trunk, leaving the middle portion entirely free. I had him laid horizontally, a board being put under the mattress to prevent its sinking in, and a cushion passed under the loins to sustain the injured part. The pain soon subsided; by the seventh day it had completely disappeared, and no longer recurred on his moving. I would add that when he became fit to get up, we examined the spine carefully; the process had resumed its normal position, and its spontaneous reduction occasioned no small surprise to all those who had satisfied themselves of its displacement.

§ II.—*Fractures of the Vertebral Arches.*

These are more commonly called fractures of the vertebral laminæ, because among the few cases known to our science, the injury seems to have involved this portion of the bone in preference. But besides the cases being so rare, they have not been described with all the exactness desirable; and a fracture seated in front of the laminæ, in the narrow neck joining the arch to the body of the bone, would give rise to phenomena and indications exactly the same, so that the two could not be distinguished from one another.

These fractures are caused by direct violence, and particularly by falls on the back. Can there be a fracture of a single vertebral lamina? If such a thing is, strictly speaking, possible, I do not believe that it has been observed; and all the known facts imply the necessity of both sides of the arch being involved.

* Aurran, *Journal de Médecine*, 1771, tome xxxvi, p. 520.

A sack of flour, weighing three hundred livres, fell on the back of the neck of a stout porter at the market-hall. Severe pain was felt at the lower part of the neck; on examination, Boyer perceived that the spine of the seventh cervical vertebra was *more prominent* than naturally. Both the upper and the lower extremities were paralysed; respiration became labored; the rectum and bladder ceased to act; and the man died in five days. The autopsy revealed *a fracture of the posterior lamina of the seventh vertebra of the neck, with depression of a fragment, which, bearing upon the spinal marrow, compressed it strongly.*

In order for the spine to have been thus prominent, it must have been detached on each side; and in order for a fragment to have been depressed, the fracture must have been triple. The double character of the fracture is clearly indicated in the following case.

A mason climbing a ladder with a hod on his shoulder, made a false step, fell backward, and struck the back of his neck against the angle of a stone. There was paralysis of the limbs, and insensibility of the skin; diaphragmatic respiration, aided only by the external muscles; priapism, etc.; death ensued two days afterwards. The autopsy showed fracture with depression of the laminæ of the fifth cervical vertebra, and compression of the cord.

These two cases show sufficiently the sort of displacement which may follow this fracture, and which is the cause of all the danger, from compression of the cord. But the fracture may exist also without displacement, or at least with a displacement so trifling as not to compromise the cord.

A man, in climbing over a carriage-wheel, fell backward, striking the back of his neck violently against the ground; his head was at the same time strongly flexed forward. On examination immediately afterwards, there was complete paraplegia, complete paralysis of the left arm; the right arm was partially paralysed and painful, the fingers irregularly contracted; there was dyspnœa, and lastly slight twisting of the mouth to the right. There was a contusion on the occiput, and a deviation to the left of the spine of the seventh cervical vertebra, with mobility of this process as well as of the laminæ attached to it. Inflammation was guarded against by bleeding, purgatives, and a blister to the nape of the neck. At the end of two months the paralysis began to diminish, and three years after there remained but slight traces of it.*

The paralysis here evidently did not depend on compression, since it at length disappeared; it doubtless resulted from some concussion or contusion of the cord itself, a lesion entirely independent of the fracture, and often met with when the bone remains entire.

* Ollivier, *Traité des mal. de la moelle épinière*, third ed., tome i, pp. 270 and 302.

The diagnosis is easy when we can grasp and move the spinous process and laminæ as in the foregoing case; still we can never be certain that the fracture does not extend to the body of the bone.

The prognosis would be extremely simple if the fracture were all; the danger results wholly from lesion of the cord. It is therefore very important to determine the nature of this lesion; it may easily be seen how the driving in of the posterior fragment should influence materially both the prognosis and the treatment.

Fracture without displacement demands merely rest in bed, the other treatment being directed wholly against present or expected inflammation of the cord. If the fragment be driven in, there is one positive indication, viz., to replace it.

Here, as in fractures of the spinous process, the ancients went beyond the mark. "The vertebral arch (*vertebrarum complexus*)," says Paulus Ægineta, "is sometimes contused, rarely fractured. In these cases, the membranes of the cord or the cord itself participating in the contusion, the pain is propagated along the nerves, and death soon ensues; particularly if the lesion affects the cervical vertebræ. In consequence, having first given notice of the danger, we should act boldly, and if possible extract by excision the compressing fragment; if this cannot be done, we must merely combat the inflammation."

Such an operation would seem to me to be at once inopportune and dangerous; inopportune, since we might resort to gentler means; dangerous, in that if the dura mater is torn we risk the introduction of air into the cavity of the arachnoid. The only case suitable for it would be that of fracture with a wound and with splinters; the extraction of the latter would then be entirely rational. Louis performed it successfully in 1762, in a gunshot fracture in the dorsal region. The patient had instantly fallen, feeling himself paralysed in the lower limbs; the wound was enlarged and the ball taken out. Louis saw him on the fourth day. Putting his finger to the bottom of the wound, he felt several loose pieces of bone, some of them of considerable size, and decided to remove them. The extraction was performed on the next day, with suitable precautions; the patient mended daily; the paralysis diminished; and twelve years afterwards he walked with a cane, his legs being still weak and emaciated, one much more so than the other.*

But when we have to treat a double fracture, without any wound, it would be proper first to try if we could not seize the spinous process with the fingers, and draw it into place; if not, we might seize hold of it with a pair of strong hooked forceps passed through the skin; and lastly, if necessary, we might resort to the curious plan

* Louis, *Remarques et obs. sur la fract. et la luxat. des vertèbres; Mém. posthume; Arch. Gén. de Médecine*, August, 1836.

proposed by Fabricius Hildanus for luxations of the vertebræ; viz., to lay bare both sides of the spinous process and hook it with a pair of firm tenacula. It would not be difficult, in cases where the displacement tended to recur, to hold the spine back by means of a ligature attached to a dorsal splint sufficiently far removed from the integuments.

Lastly, when the fracture has united with marked displacement, and paralysis seems to be kept up by the compression, does our art possess any resources? Dr. Alban W. Smith, of Kentucky, has attempted to answer this question by the following case.

A young man having fallen from a horse, had all his members paralysed, except the muscles above the elbow on each side. Dr. Smith found one of the dorsal spines deviated about three lines to the right; he concluded that the vertebra was completely dislocated, and judging the case a fatal one, made no attempt at reduction. The patient however survived, and two years afterwards another surgeon was consulted, who having made an exploratory incision down to the bone, considered that there was merely fracture of the base of the spinous process, compressing the cord. With this assurance, and being urged to it by the patient, Dr. Smith proceeded to operate; he made an incision of five or six inches along the dorsal spines, and at each end of this two others transversely, of three and a quarter inches each, down to the bone. The muscles were then detached from the vertebræ on each side, down to the transverse processes, and the bones properly rasped; and thus the diagnosis was verified. The fragments were displaced laterally, but so completely fused, and offering so smooth a surface that the line of separation was not well marked. With a Hey's saw, the operator divided first each side of the second dorsal vertebra, as near as possible to the bases of the transverse processes; and in fact resected and raised up a portion of the spinous processes of two vertebræ, half that of the third, and all that of the fourth, which seemed most deeply driven in. No bad symptoms ensued; sensibility was regained in the thighs and in the hands, auguring well for the future re-establishment of motion. Unhappily the account terminates here.*

This observation is open to more than one criticism. All the dates are omitted; the seat of the lesion is not stated; but, above all, the diagnosis was made out carelessly, the operation undertaken yet more rashly, and the final result remains unknown. It is not upon such cases as this that we can found any positive opinion.

* *North Amer. Med. and Surg. Journal*, July, 1829, p. 94. This case has been reproduced in the *Journal des Progrès* and the *Journal Hebdomadaire*, but with a discreditable misinterpretation.

§ III.—*Fractures of the Bodies of the Vertebræ.*

The causes of these fractures are very various. Most commonly they are falls from heights, the posterior aspect of the trunk striking the ground; sometimes in the fall the trunk strikes against something upon which the spine is broken; thus masons or carpenters, falling from scaffolds, strike beams, bars of wood or iron, etc. Sometimes again the person lights on one extremity of the trunk,—the pelvis or the head; in the latter case the head is sometimes bent forward, when the force comes on the occiput, and sometimes it is thrown backward, when the force comes on the forehead. Several instances have been reported also of fractures following falls on the feet. Lastly come blows on the spine, which mainly result from falling bodies, or banks caving in; strong pressure, gunshot wounds, etc.

Reveillon has related a case of fracture due, according to him, to muscular contraction. A soldier having dived from a height into some water not more than three feet deep, was taken out some minutes after, with paralysis of all his limbs. On coming to himself, he said that having touched the bottom with his hands, he threw his head suddenly back in order to save it, and from that instant was unconscious. He died in the night, and at the autopsy there was found a transverse fracture of the body of the fifth cervical vertebra, and separation of the laminæ from the lateral masses.*

However this may be, on examining closely the mechanism according to which these fractures take place, we come strongly to doubt the doctrine of Boyer, who admits only direct causes, and even that of some modern authors, who consider them more common than the indirect. It is certain first that, in falls on the head, on the pelvis, or on the feet, the fracture occurs by counter-stroke; and when a heavy body falls on the head or shoulders, causing forcible flexion forward, the counter-stroke is no less evident. There remain then falls on the back; now when no small projecting body is encountered, breaking directly one or two vertebræ,—as for instance when the ground is level,—nearly always the chief shock is sustained by one of the most prominent points, the head, the upper part of the back, or the sacrum; and in the second case, the only one in which the spinal column is directly involved, the shock is usually diffused over too large a surface to produce direct fractures.

I assume, then, that in fact, in the great majority of cases, fractures of the bodies of the vertebræ occur by counter-stroke, as the effect of forcible flexion of the column either forward or backward; and the usual seat of these fractures demonstrates this. I have else-

* *Journal Général de Médecine*, tome xcviii, p. 418.

where shown that the spine bends at three principal points,—comprised, the first between the third and seventh cervical vertebræ, the second between the eleventh dorsal and second lumbar, the third between the fourth lumbar vertebra and the sacrum.* Now the majority of fractures involve the vertebræ situated between these points of flexion; and luxations follow the same rule. Ollivier's work contains twelve cases of fracture of the bodies of the vertebræ; three are of the sixth and seventh cervical; five are between the tenth dorsal and first lumbar; the four others occupied the fourth, fifth, seventh and eighth dorsal vertebræ. The distribution is still more significant in the observations of Dupuytren. Excluding two cases of gunshot, there are thirteen cases in which the seat of fracture is clearly indicated; in five cases it occupied the fourth, fifth and sixth cervical vertebræ; in all the rest it was about at the last three dorsal and the first lumbar. Finally, the Musée Dupuytren contains five specimens relative to these fractures; one involves five of the cervical vertebræ at once; the four others are at different points between the tenth dorsal and the second lumbar.

These fractures present quite numerous varieties, which would perhaps be explained by the variety of the causes, if the latter were always more precisely recognisable; the principal are transverse fracture, crushing, and oblique fracture.

We have already had an instance of transverse fracture in the soldier treated by Reveillon; here, whatever opinion we may adopt as to its cause, the mechanism of the fracture still remains the same; there was forcible flexion backward. Ollivier reports a case of transverse fracture of the seventh dorsal, and another of the first lumbar vertebra, one caused by a fall on the back, the other by a bank caving in; it is quite likely that both these causes acted likewise by producing forcible flexion backward.

Crushing or comminution seems on the contrary only attributable to forcible flexion forward. It presents itself in various degrees; sometimes the body of the bone, when comminuted, loses very little of its thickness; sometimes it is reduced by one-half or more; in the Musée Dupuytren are two striking examples of these two first forms. In a still higher degree, the body of the bone is almost entirely destroyed; of this Ollivier has given a remarkable instance. A more singular variety is where the anterior portion of the body is crushed, and reduced to a few lines in thickness, while the posterior portion remains intact; this was seen in a water-carrier who had been overthrown by a heavily filled cask, the edge of which struck him violently at the lower part of the dorsal region.†

Oblique fracture probably occurs from causes analogous to those

* See my *Anat. Chirurgicale*, tome ii, p. 15.
† Ollivier, *op. cit.*, obs. 20 and 26.

of crushing; it is very remarkable that in all the known cases of it, its direction should be from above downward and from behind forward, so as to favor the overlapping of the fragments if the apophyses and ligaments situated posteriorly did not prevent it; of this there are two beautiful specimens in the Musée Dupuytren.*

There are some other varieties, but they are in a manner irregular, and it would be idle to dwell upon them.

Lastly, these different fractures may be isolated, the rest of the vertebra being intact, or they may be conjoined with fractures of the laminæ and of all the apophyses; perhaps it would be correct to say in a good many of these cases that the fractures of the arch are by direct violence, and those of the body by indirect.

[I have recently had an opportunity of examining two specimens of fractures of the cervical vertebræ; in both cases the patients were men aged 19 or 20 years, and in each the cause had been a fall head-foremost through a hatchway. One lived ten days, and the other eleven, after the occurrence of the injury; both died with symptoms of slow suffocation.

Case I.—Vertebræ involved, the 4th, 5th and 6th.

4th. Vertical fracture affecting the posterior portion of the body; right lamina broken through, but undisplaced, a piece being chipped off; partial fracture of right lateral mass.

5th. Complete vertical fracture of body and of right lamina, and lower anterior edge of body chipped off. (This vertebra had slipped forward so as to be dislocated from the 6th.)

6th. Partial vertical fracture of the body, affecting its upper and anterior portion.

Case II.—Vertebræ involved, the 5th, 6th and 7th.

5th. Arch broken through close to root of spinous process.

6th. Comminuted fracture of body, vertical posteriorly and transverse anteriorly; arch broken off at each side just behind the lateral mass, entire arch sunk down upon that of the 7th.

7th. A small piece chipped off the upper anterior edge of the body, which also presented an extensive but incomplete transverse fracture in its upper portion.]

The most constant phenomenon of these fractures is severe local pain, augmented by voluntary motion and by pressure with the fingers. Another, almost as constant, is paralysis of all the parts whose nerves take their origin below the fracture. This paralysis results sometimes from the tearing or compression of the cord by the displaced fragments; but more commonly it is due to a lesion of the cord independent of the fracture, as has been already said. Lastly, but exceptionally, the fragments are so distorted as to furnish both to the eye and to the touch plain indications for the diagnosis.

* See the *Atlas of the Musée Dupuytren*, pl. i and ii.

The displacements are of three kinds. Sometimes one of the fragments passes forward, the other remaining in place; this is seen in some transverse fractures, and it is always the upper fragment which slips forward. If the fracture is oblique, the upper fragment slides forward and downward, sometimes to such an extent as to be entirely in front of the other. When there is crushing of the bone, the displacement is almost entirely by penetration, the upper part of the column being at an angle with the inferior; this angle is always and essentially open anteriorly, rarely with some inclination to one side or the other. If any sliding occurs of the two portions one on the other, it is still the superior which passes forward, so that in all these fractures, if there is displacement, the general law is that it should be the upper fragment which is anterior.

The necessary consequence of these displacements is deformity of the vertebral column, which should be easily perceived posteriorly in the median line, where the spinous processes are covered only by the skin. When the upper fragment is carried forward, the spinous processes above the fracture should be less, and those below it more, prominent; and at most we should doubt whether it were a fracture or a luxation. When there is overlapping or crushing, the angle in front, an entering one, is represented posteriorly by a salient one; sometimes this prominence is due only to the spine of the vertebra involved. In the water-carrier who had only the anterior portion of the body of the bone crushed, the prominence was rounded, formed by three spinous processes separated from each other by two fingers'-breadths.

Who would not suppose that in these cases, at least, the diagnosis would be easy? And yet in a young girl who had had the body of the fifth dorsal vertebra completely crushed, MM. Dumeril, Roux and A. Dubois did not recognise the fracture.* Swelling, pain, and sometimes *embonpoint*, are obstacles to an examination regarded at any rate as but of moderate utility. Moreover, fractures of the posterior arch and its apophyses, in place of affording any light, often serve only to mask the most fearful displacements. Of this a curious instance is given by W. Lyon. In a patient, the autopsy upon whom showed complete overlapping of the upper vertebra in front of the lower, there had been during life only a slight prominence posteriorly. This was because the spine of the upper vertebra, fractured at its base, became horizontal instead of maintaining the obliquity proper to the apophyses of the dorsal region, thus filling up in great part the space which the displacement would otherwise have left at this point.† It will readily be seen that the difficulty increases as the displacement becomes less; and when fracture occurs without displacement, the diagnosis is absolutely impossible.

* Ollivier, *op. cit.*, obs. 20.

† *Gazette Médicale*, 1845, p. 43.

The prognosis is very doubtful, and most commonly very grave, much more from the lesion of the cord than from the mere fracture, although the crushing and overlapping of the fragments may, if at all marked, leave the patient irremediably deformed. Sir A. Cooper shows that in the lumbar region fractures with displacement prove fatal generally in about four or six weeks; in the dorsal region, in two or three weeks; in the three lower cervical vertebræ, from the third to the seventh day; above the third vertebra, almost immediately, by causing paralysis of the phrenic nerve. In connection with luxations I shall recur to the entire history of the symptoms induced by lesions of the spinal cord. But Sir A. Cooper's rule for the prognosis would involve too serious consequences as to our treatment, unless reduced to its true value.

In the first place, he alludes only to those great displacements in which the upper fragment slips from the lower by half an inch or an inch; and he himself cites notable exceptions to his own rule. Thus he saw a patient with fracture about the loins survive the accident for two years; others, with fractures in the dorsal and lower cervical region, for nine or ten months; and I could myself give other instances. Doubtless the displacement in them was not an inch, or even half an inch; but as it is impossible to measure its extent during life, we should evidently not give up all hope too soon. I have seen at Bicêtre a patient completely paralysed in both lower limbs in consequence of the caving in of a bank, fracturing, as well as could be judged, one of the lumbar vertebræ; the accident had occurred more than six years before.

[Two cases diagnosed as fractures, one at the lower part of the dorsal and the other at the middle of the lumbar region, are reported for the *Am. Journal of the Med. Sciences* for October, 1857, by Dr. Lente, of Cold Spring, N. Y. In both, very satisfactory results were obtained.]

The treatment, with most surgeons, amounts to very little; the patient is to be laid on his back, on a mattress supported by a board, his head somewhat raised; he is to be so fixed by means of folded cloths, etc., as to favor consolidation; inflammation of the cord is to be combated; the consequences of paralysis to be guarded against; such are the indications generally admitted; and when no sign of displacement exists, such is in fact the line of practice to be followed.

But when we have reason to suspect displacement, should we remain passive spectators, or should we attempt reduction? I have given my views on this point as to simple fractures of the posterior arch, and a series of plans to be tried even if the body of the vertebra should be involved. But in the body of the bone itself, what reasons are there against reduction? Sir A. Cooper believes it impossible to be performed or to be maintained; others add that there is danger of increasing the compression of the cord, or of forcing

splinters into its substance. The objection to reduction, as being impossible, is nullified by facts, as will be seen in connection with luxations; the objection that it is dangerous is still more trivial; the danger lies in our inaction, and is too great for us to dread increasing it.

In 1843, at the Hôpital des Cliniques, I had to treat a case of fracture in the lumbar region, with prominence of the spinous process, and paraplegia; I placed under the upper portion of the mattress an inclined plane of forty-five degrees, and the trunk was fixed thus at this angle by means of a cloth folded cravatwise, passed under both armpits, and fastened at the head of the bed. At the same time cushions were made to support the loins, so that I used at once extension and pressure, to lessen the sinking in which I presumed had occurred in the body of the bone. The paralysis passed off before long, and the patient recovered without difficulty.

This was the only case in which I have thought fit to resort to extension; and this position being very fatiguing, I should now prefer laying the patient on his back, making extension at first with a loop under the armpits, and another round the pelvis; rendering this permanent, if necessary, by fixing the loops to the head and foot of the bed, and placing cushions beneath the seat of fracture. Mr. W. Tuson, in England, obtained from temporary extension such remarkable results, that even allowing for some little exaggeration, they should fix the attention of surgeons. A man fell from the top of a carriage, striking on his back; he heard at the moment of his fall a crack behind his neck; his legs were entirely paralysed; there was priapism; and on examination of the spinous processes of the seventh cervical and first dorsal vertebræ, where the force had been sustained, a slight displacement was perceived. Tuson had his head held firmly, drawing at the same time strongly and steadily on his legs; the man immediately said he was well, and raised up and moved his legs; the priapism ceased. However, the cure was not completed, nor the powers entirely restored, until after about five months.

In contrast to this simple and regular plan, for which experience will present us with new arguments in connection with luxations, another doctrine has been put forth, the first traces of which date back to the times of Paulus Ægineta, but which, until our time at least, has remained purely theoretical; I allude to the use of the trepan. Chopart and Desault are the first to speak of it, as a very simple thing, *to trepan between the spinous and transverse processes, to give issue to effused fluids, to elevate or remove pieces of bone which may wound the cord;* but Boyer, wiser this time than in regard to fractures of the cranium, objects strongly that we have no sign by which to distinguish between compression by a piece of bone or by an effusion, and any other lesion of the spinal marrow. Still,

Sir A. Cooper did not hesitate subsequently to give his imposing approbation to this proceeding. "Mr. Henry Cline," says he, "is the only man who has looked on this indication in a scientific light. He considered the case as entirely similar to fracture of the cranium with depression, and as offering the same demand for relieving the compression; and as such cases always terminated fatally, he thought himself justified in deviating from the usual path in the hope of saving life. The patient lying on his face, an incision was made over the depressed bone, and the muscles covering the vertebral arch were raised up; a small trepan was then applied to this arch, dividing it on each side, so that the spinous process and the arch pressing on the cord could be elevated." The patient died. Sir A. Cooper even adds that he is not sure that the operation ever could succeed; still in desperate cases he would consider it *laudable*.

In 1822, an occasion was again afforded for trying it; and encouraged by Sir A. Cooper, Tyrrell removed, either with the trepan or with suitable saws, the spines and laminæ of the ninth and tenth dorsal vertebræ; the patient died on the fifteenth day. The same operator made another attempt in 1827; with a chain-saw and a Hey's saw he removed the spine and arch of the twelfth dorsal vertebra; the performance occupied more than three-quarters of an hour; death ensued five days afterwards. Dr. J. Rhea Barton is said to have done the same, with the same result. Lastly, in 1840, M. Laugier applied a crown of the trephine at the base of the spinous process of the ninth dorsal vertebra, so as to enlarge the canal without removing the apophysis; the subject died on the fourth day.*

[An account of Dr. Barton's operation may be found in Dr. John D. Godman's edition of Sir A. Cooper's "Treatise on Dislocations and Fractures of the Joints," p. 421. It is as follows:—

Dr. Barton's "views relative to this operation are very ingenious and deserving of consideration. His object in cutting down to the vertebræ is not the mere elevation or removal of a depressed or fractured portion of the bone, but the excision of as many of the spinous processes as are external to the angle formed by the dislocation of the vertebræ. This he thinks will allow the spinal marrow to curve outward so as to free it from pressure, and also allow matter or effused blood to be readily discharged.

"J. P. was received into the Pennsylvania Hospital, August 18, 1824, with a fracture of the spine, caused by a fall from the masthead of a brig. The lower part of the trunk, and the inferior extremities, were totally paralysed. He continued in this state, discharging his feces and urine involuntarily, until the 30th of August, when Dr. Barton performed the following operation. An incision

* See for these different cases, Ollivier, *op. cit.*, tome i, p. 381; *The Lancet*, vol. xi, p. 685; Laugier, *Bulletin Chirurg.*, tome i, p. 401.

was made about eight inches in length immediately over the injured vertebræ. He found the spinous process and arched portion of the seventh dorsal vertebra broken off and depressed on the spinal marrow. When this was done it was ascertained that the bodies of the seventh and eighth dorsal vertebræ were dislocated from each other, without any fracture but that above mentioned. Lint was laid over the wound. The paralysis not being immediately relieved, it was inferred that compression was kept up by blood effused within the spinal canal, which would possibly escape with the suppuration from the wound.

"About forty-eight hours from the time of operation, sensibility began to return below the injured vertebræ, and gradually extended toward the toes until the third day, when he was attacked with a violent chill, which continued, notwithstanding all the stimulating medicines given, until his death, which occurred in twelve hours from its commencement.

"An examination was made next day, to ascertain the real state of the spinal column. On opening the thorax, the posterior mediastinum was found filled by about half a gallon of coagulated blood, which accounts for the difficulty of respiration, especially when he lay on his back. This being cleared away, the condition of the vertebral column was seen. The seventh and eighth dorsal were injured as before stated, the body of the ninth was fractured, and blood was effused throughout the spinal canal."

A writer in the *Brit. and For. Med. Review* for 1838 (page 162,) reviewing Sir C. Bell's "Institutes of Surgery," says:—"We are free to admit that the cases in which an attempt has been made to elevate a depressed portion of the spine have not been very successful. We know of only four cases; and of these, one was performed successfully, as we are informed, only a few months ago, by a surgeon of the name of Edwards, living at Caerphilly, in South Wales. There were present the usual symptoms of compression,—paralysis of the organs of locomotion, the rectum, and the bladder; the situation, as far as the operation was concerned, was unfavorable,—the lumbar region; the posterior arch of the bone was raised, the symptoms of compression relieved, and the patient did well."

Dr. Norris informs me that this latter case is the only one with a successful result out of ten of which he has collected notes. One operation, done by Potter of New York, three months after the receipt of the injury, was followed by a return of sensibility for a short time; but the patient died on the eighteenth day.]

These results should be sufficient to deter surgeons from so grave an operation. I would add, in answer to Sir A. Cooper, that it is not accurate to call it our only scientific resource. In every fracture with displacement, the most scientific and rational plan is first to attempt reduction by the ordinary methods; and to this rule fractures

of the vertebræ do not constitute an exception. If the ordinary methods are not sufficient, we may try to act on the posterior fragment with forceps or tenacula, to draw it backward; and the extraction or trephining of the arch presents itself as so desperate a resource that I would not advise any one to adopt it. I say desperate, I should say also blind, for at least hitherto it has always been undertaken at great risk, and has never been justified by the results. Take the completest case, that of M. Laugier; on examining the dorsal region of the patient, *there was no deformity found along the spinal column.* Whence then the indication for operating, and what the object in view? I cannot divine. The risk at any rate, that melancholy and feeble argument,—could it afford to the operation an unhoped-for justification? Not at all; neither in the details of the operation, nor in those of the autopsy, do we find anything indicating any pressure from the part of the arch which was trephined; and had such pressure actually existed, a last counter-indication was revealed by the scalpel,—the cord was entirely broken across.

CHAPTER VI.

OF FRACTURES OF THE RIBS.

FRACTURES of the ribs are among the most common of all fractures; they amount to 263, or just one-ninth, of the 2358 cases at the Hôtel-Dieu. The influence of the seasons in their production seems to be nothing; but it is quite otherwise with age and sex. Of the 263 cases at the Hôtel-Dieu, forty-eight only, about one-fifth, occurred in females. The following table will show the influence of age:—

At 9 years	1	(compound.)
From 15 to 20 years	2	
" 20 to 30 "	11	
" 30 to 40 "	48	
" 40 to 50 "	72	
" 50 to 60 "	68	
" 60 to 70 "	49	
Above 70 years	12	

Whence we see how rare these fractures are in youth, and how common in old age. For my own part, I have never seen one under fifteen years of age; while in the two years which I spent at Bicêtre, the fractures of the ribs alone were nearly as numerous as those of all the other bones put together. In infancy, the elasticity of the ribs permits of their resisting the most violent pressure. Thus A. Paré has related the case of a child two years old, over whose chest a carriage with five persons in it passed twice, without any indication of fracture of the ribs.* In adult age, this elasticity is lost, still more from the ossification of the cartilages; but besides, the ribs are subject to a kind of senile atrophy, affecting them chiefly in their thickness, and making them much more fragile. This atrophy, which I have nowhere seen mentioned, is observed also in some affections of the interior as well as of the exterior of the chest; I have ascertained its presence in a case of pulmonary emphysema; I have seen the same in a woman affected with cancer of the breast, not adherent to the ribs or even to the great pectoral muscle,—I

* A. Paré, edition by Malgaigne, tome iii, p. 489.

have seen, I say, all the subjacent ribs so much thinned as to present a thickness three or four times less than that of those of the opposite side.

The usual causes are external violence, a severe blow, an excessive pressure, or a fall on some projecting body, as the edge of a step, the angle of a table, or even a fall from a height to the ground. Lonsdale has seen nine or ten ribs on each side broken by the last-mentioned cause.

How do these various causes act? J. L. Petit has given a theory as to this, which still prevails in our schools; the rib according to him represents an arch, which may have its middle portion driven in, *fracture inward*, called also *direct;* or perhaps a pressure exercised on both ends, tending to approximate them, forces the middle portion outward, *fracture outward*, or *indirect*.

This theory is correct only within certain limits. Thus a blow or strong pressure, acting on the middle of the rib, causes frequently only a direct fracture; but it sometimes also occasions indirect fractures at other points; and it is thus that multiple fractures occur. We need not however suppose from the expression *fracture inward*, that the rupture always commences with the inner table of the rib; sometimes it is confined entirely to the outer one. A man seventy-seven years old fell against the arm of a sofa, and broke five ribs, from the third to the seventh, on the right side; he died on the third day. At the autopsy I found in four of the ribs complete fractures; but the fifth, the one in the middle, had the external table only broken; the inner one had bent, and formed an angle salient inwardly. *Fig.* 10 shows this specimen as seen from within, and the angle formed by the partially broken rib in the middle.

As to indirect fractures, produced by pressure on both ends of a rib, they do not, as was believed by J. L. Petit, occupy the middle portion of the bone. I have frequently tried breaking the ribs by powerful pressure on the sternum, and the fractures have always occurred anteriorly, generally even nearer to the sternum than to the middle of the rib.* In several cases of indirect fractures caused in the living body by wheels passing over the sternum, I have observed the same fact; and at the time of the sad occurrence in the Champ de Mars, in 1837, seven persons having died from fractures of the ribs arising probably from indirect violence, all the fractures were found in front, from two to seven millimètres or more from the cartilages.

It is otherwise when the pressure is applied posteriorly, the subject lying on his face. In a case reported by Zwinger, the man

* Malgaigne, *Recherches sur les var. et le trait. des fract. des côtes; Archiv. Gén. de Méd.*, July and August, 1838. I would refer the reader to this memoir for the sources of any quotations which may have been omitted in this chapter.

being thrown down on his face, a horse and a heavy carriage passed over his back. Singularly enough, the fractures in the lower ribs were seated anteriorly, even in the very cartilages, while the three upper ones were broken and depressed close to the spinal column.

Fractures from internal causes have been overlooked by most surgeons. I have collected seven such instances, related by Gooch, Monteggia, Graves of Dublin, C. Broussais, and Nankivell; another has been observed at the Hôpital Necker.* Of these eight cases, four occurred in men and four in women. The age is given in six; five were in persons between forty-seven and sixty-three years of age; the sixth was in a young man. In seven cases the cause was manifestly a severe effort at coughing; in that of M. C. Broussais, the patient having been unable to give any particulars, but having at the same time chronic pneumonia and eccentric hypertrophy of the heart, it might be questioned whether the beating of the heart had not some share in the production of the fracture, which occupied the fourth true rib, at the junction of its anterior fourth with the rest of the bone. It is very remarkable that in all the cases in which the seat of the fracture has been indicated, this was somewhere in the anterior half, and generally near the cartilages; what is not less remarkable is that so far no instance has been known of such a fracture occurring on the right side. In the cases hitherto known, the ribs involved have been the fourth, fifth, and sixth, then the ninth, tenth, and eleventh, the seventh and eighth being exempt. Generally but one rib is affected; once only the fracture occurred simultaneously in the fifth and sixth; and in the likewise curious case at the Hôpital Necker, there took place in less than one month three successive fractures, affecting first the tenth, then the ninth, and lastly the eleventh rib. On the whole the tenth seems to be the rib most exposed.

I think it very probable that in all these cases the ribs had undergone more or less of the atrophic thinning of which I have before spoken; and that the fracture was induced by muscular action, which in coughing approximates the sternum and the spinal column, just as exterior pressure does.

Fractures of the ribs present numerous varieties of seat and arrangement. The middle ribs are naturally more exposed; the first, being protected by the clavicle, and the last, which is small and floats freely among the tissues, are very rarely involved, and perhaps never alone. In one case related by Derrecagaix, the last rib was broken along with the seven immediately above it; in another, by M. J. Cloquet, the four last ribs on the left side were all broken at once, each at two different points.† Again, M. Lisfranc saw the upper six ribs

* *Gazette des Hôpitaux*, February 6, 1841.

† *Journal de Desault*, tome iii, p. 9; *Dict. de Méd.* en 30 vol., art. *Côtes*.

fractured at once, and Chaussier the first nine; it is remarkable that in neither of these cases did the clavicle suffer.

In general, these multiple fractures affect but one side of the chest; sometimes both sides are involved; I have already quoted Lonsdale's case, and Ollivier d'Angers, in one of the persons killed at the Champ de Mars, counted as many as thirteen ribs broken. In reference to each rib in particular, fracture may affect any portion of its extent; but the anterior part is more exposed than any other.

As to their arrangement, fractures of the ribs may be complete or incomplete, single or multiple.

Incomplete fractures are sometimes mere fissures, following the length of the rib, or perhaps a fissure, involving one edge, and then running along the rib without reaching the other. M. Lisfranc satisfied himself as to the occurrence of these two forms in an autopsy on a young girl overset by a cabriolet. It is much more common to find the fracture limited to one table of the bone; Cheselden, Michault, and Chaussier, have reported instances of fracture of the inner table; and I have already mentioned *Fig.* 10 as a good example of one of the outer.

Among complete single fractures, some are transverse or oblique, presenting a clean crack, so that the fragments are held in contact only by the periosteum or by the muscles, and may be moved upon one another so as to cause crepitation. But more frequently, perhaps, the fracture may be serrated; and then, although we can rub the fragments together, we cannot generally so disengage them as to produce crepitus.

Multiple fractures are far more diversified. Sometimes, as in Chaussier's case already quoted, there are two partial fractures; sometimes a complete fracture is conjoined with an incomplete one, or perhaps both are complete; and lastly, I have examined anatomical specimens presenting incontestable traces of three or four fractures in a single rib. I say nothing of comminuted or splintered fractures; they often occur when a rib is broken by gunshot; but to my great amazement, I have not found a single such case produced by ordinary causes, and on the dead subject I have not been able to obtain them.

The symptoms of these fractures vary as much as their form.

Some patients say that at the time of the blow they heard the crack of the bone; but that is nothing less than common. It is quite as rare to find any contusion or ecchymosis externally.

The most constant phenomenon is local pain, increased by the movements of respiration, especially by strong inspiration, by exertion, and by coughing; by external pressure; sometimes, more or less, according to the seat of fracture, by movement of the shoulders.

It begins from the instant of the injury, and is only allayed by rest or immobility of the thorax, and by the reduction of the fragments.

In the simplest fractures, when care has not been taken to render the chest motionless, the pain usually persists; sometimes the slight irritation which occurs around the fragments is propagated to the pleura; if the ear or the stethoscope be applied, we shall hear a friction sound denoting slight circumscribed pleurisy; and I have seen a fracture of a rib, placed by mistake in a medical ward, give rise in this way to an odd error in diagnosis. On the other hand, a bandage being applied, the pain promptly subsides; many patients in hospitals request to be discharged about the eighth to the tenth or twelfth day, a period when osseous consolidation certainly cannot yet have occurred.

When the fracture is multiple, and one fragment is driven in, the pain is deeper and more fixed, and seems due to contusion and partial inflammation of the lung and of the pleura; the bandage, so far from alleviating, often exasperates it; I have sometimes then seen the thorax, either by reason of the pain, or from the irritation and tension of the muscles, become of itself immovable on the affected side, the costal respiration being carried on exclusively by the sound side.

The decubitus, in these cases, has not seemed to me to follow any general rule; I have seen some patients who could only lie on the sound side; others, on the contrary, who could only lie on that affected; and others, again, in whom it was a matter of indifference; and I have as yet been unable to detect the cause of these anomalies.

It might be presumed, from the incessant movement of the ribs, that crepitation would commonly exist, and even be heard without any effort to induce it. I have seen a remarkable case of this in a man aged 32, with a simple fracture of the ninth rib on the right side, which from the fourth to the fourteenth day produced a crepitus perceptible by himself as well as by others, in certain movements, and in somewhat deep inspirations. Chaumette observed something much more remarkable in his father-in-law, Claude Chillac, who sustained a penetrating wound of the thorax, opposite the heart. "*Il auoit aussi vne coste rompue,*" says he, "*et entendions aisément son remuement lorsque le cœur se mouuoit.*" But all this is excessively rare; very often, on the contrary, whether from incompleteness or impaction of the fracture, or from swelling of the surrounding parts keeping the two fragments in contact, all attempts at producing crepitation are unsuccessful.

The displacements remain to be studied. J. L. Petit, as has been seen, alleged that the two fragments might be driven either outward or inward by the violence, while admitting that the intercostal muscles would prevent them from being greatly deranged; and Vacca Berlinghieri, over-estimating the resistance of these muscles, went so

far as to deny the possibility of displacements. All this is pure theory, and cannot stand before the facts.

In fissures, in the great majority of incomplete fractures, and in complete fractures when serrated and unattended by rupture of the periosteum, there is no displacement of any kind. In some simple incomplete fractures, situated near the sternum, there may be angular bending of the rib inward, with a corresponding depression outwardly; this I have seen in several specimens; I have been able to cause it in the dead subject, and *Fig.* 10 affords an instance of it.

Complete fracture, when the fragments are held in place neither by their serrations nor by the periosteum, is almost always attended with real displacement; thus the anterior fragment projects sometimes backward, sometimes forward—sometimes upward, and sometimes downward; all these forms I have observed in specimens. These projections are usually very slight, mostly limited to one or two millimètres, except toward the anterior end of the rib, where, by a mechanism which can be better explained in connection with fractures of the cartilages, they may reach four millimètres or more. M. Voisin has published an account of an autopsy in which he found a fracture of the second rib three inches from its cartilage, with an overlapping of nearly half an inch.* But overlapping is more common in fractures involving several ribs, as will be presently shown.

When, along with an incomplete fracture, there exists at some distance from it a complete one, the middle fragment is generally notably driven in; it makes an angle salient outwardly with the fragment to which it still holds, but it leaves the other more or less entirely; of this I have seen four instances. In all these cases, the fractures had occurred from the passage of a carriage-wheel; and the pain was intolerable. We have reason then to fear lest the fragment driven in may have penetrated the lung; hence sometimes emphysema, effusion of blood into the pleural cavity, or traumatic pneumonia.

Lastly, when the rib is completely fractured at two, three, or four points, sometimes there is little or no displacement, sometimes it is very great. Sabatier saw a case of this kind, in which the mere play of the lung had given rise to a very curious displacement. The last two true ribs had been fractured by the passage of a carriage-wheel; but the lower one was broken in two places, and in such a way that the middle fragment, being quite movable, was drawn into the chest in inspiration, and pushed outward in expiration. [Probably the author meant just the reverse of this; the fragment would be *pushed outward* in *inspiration*, *drawn in* in *expiration*.] Sabatier adds that the patient recovered perfectly.† This is certainly quite an exceptional case; generally, judging from the anatomical

* *Gazette Médicale*, 1832, p. 465.

† *Mémoires de l'Institut*, tome vii, an vii, [1799,] p. 119.

specimens that I have seen, one of the ends of the middle fragment has projected outwardly, while the other was driven inward.

Hitherto I have alluded only to displacements in fractures of single ribs; they are much more marked when several are broken at once; and they differ again according as the fragments are few or many.

Fig. 9 presents a fine example of simple fractures of eight ribs, from the second to the ninth inclusive. As, owing to these simultaneous fractures, the ribs could no longer support one another, there has resulted in several of them an actual overlapping to the extent of more than a centimètre. In the upper four, the sternal fragment has passed above the other; in the rest it has remained at the same level, or even been a little driven in. It may be seen also to have generally descended a little below the vertebral fragment. But what is much more remarkable is the narrowing of most of the intercostal spaces, carried so far as to result in fusion of the sixth, seventh, and eighth ribs. The first cause of this is doubtless the overlapping, which, by shortening the ribs, necessarily diminishes the diameter and the circumference of the chest; but I think we should add to this the muscular irritation excited by so great an injury, which would have the effect of forcing the ribs still more closely together. The specimen was presented to the Musée Dupuytren by M. Poumet.

When multiple fractures exist in several ribs at once, as from the passage of a wheel over the chest, the displacement is different again; and often even in the living subject the very first glance puts us in the way of making up our diagnosis. We perceive a hollow, more or less wide and deep, marking on the surface the course of the wheel; and if on exploring it with our fingers we feel no projection of one of the fragments, if increased pressure augments momentarily the depression without causing any projection, we may affirm the existence of multiple incomplete fractures. I have published quite a remarkable case of this, where the fourth and fifth ribs on the left side presented such a depression without any prominence, while in the sixth and seventh complete fracture was indicated by very marked projections.

From all that precedes, it may be concluded that the diagnosis is very often obscure and equivocal. When, as the result of external violence, there is fixed pain, localised somewhere in the course of a rib, with the characters pointed out above, but without any other sign, we may suspect, but not affirm, the existence of fracture; for it may be that there is only a contusion. This would be a probable diagnosis merely.

If any displacement can be clearly made out, the diagnosis becomes certain. But here also there are sources of error. When the displacement forms a wide hollow, we must ascertain that there has been no former lesion, as rachitic distortion or old fracture. The

insertions of the external oblique and serratus magnus might induce us to suspect depression of one fragment and projection of the other, by reason of their sudden swell under the fingers, especially when they are contracted with the pain. Many subjects present also remarkable prominences at the junction of the ribs and their cartilages, owing to abrupt enlargement of the ends of the bones.

Crepitation forms, here as elsewhere, the true pathognomonic sign; it cannot be simulated except by emphysema, which is of very rare occurrence, and easily diagnosed. But to obtain crepitus is often very difficult. It has been advised for this purpose to press alternately on the fragments; a plan specious in theory, but nearly always useless in practice. The means which has seemed to me most efficient consists in applying over the part the palmar face of four fingers, and then making the patient cough; but the surgeon should bear in mind still that this may not at first succeed; and that even after having once perceived crepitus clearly, the process may be several times repeated in vain.

The prognosis is very simple in uncomplicated fractures. Consolidation rarely fails to occur, even in animals, when no apparatus is applied; and it only takes twenty-five or thirty days. I have seen but a single instance of non-consolidation in a fractured rib; M. Huguier told me that he had not met with one in the dead body. The articulation in my case was remarkable in having a capsule and a synovial membrane; which shows that the two fragments must have executed from the first quite extended movements upon one another.

In fractures with irreducible depression or overlapping, it is to be feared that the patient will have at the point of injury a dull pain, very slow to disappear; but this is not constantly the case. When, lastly, we have to deal with either single or multiple fractures involving several ribs at once, the prognosis becomes much graver; not on account of the fractures themselves, but because of the accompanying symptoms. Sometimes a fragment, driven in, penetrates one of the cavities of the heart; Lonsdale and Dupuytren saw instances of this.* Death is then almost immediate. Amesbury relates a case in which, three ribs being broken, death ensued by hemorrhage from the intercostal artery, without any lesion of the lungs. But much more frequently the lungs are contused, broken, or torn; the patient may then survive some hours or even days. If the pulmonary lesion is less severe, there may ensue only an external emphysema, hardly demanding any attention; or the pleura and lung may become inflamed, and increase again the chances of death. This may suffice to explain the exceptional mortality of these fractures. Of the 263 cases at the Hôtel-Dieu, there were twenty deaths, twelve of which occurred from the first to the fourth day, five from the

* *Gazette des Hôpitaux*, June 1, 1830.

seventh to the eleventh, and three from the seventeenth to the twenty-fifth.

The treatment commonly followed in fracture of the ribs is based on the theories of J. L. Petit or of Vacca. According to the latter, as there is no displacement, the only indication is to render the ribs immovable; according to the former, when the fracture is outward we should exert upon it a permanent pressure to push the fragments inward; and when it is inward, we should press at once on both extremities, so as to push the fragments outward. The reader will know how to value these theories; we therefore lay them aside, and examine the indications.

If the fracture is without displacement, there is manifestly no reduction to be made. If there is very slight displacement, or even when, owing to several partial fractures, there is perceptible depression, but no pain except that arising from movement or from respiratory efforts, reduction is of trifling importance, and calls for the use of too much force. In all these cases, then, the only indication is to fix the chest, so as to dissipate the pain and insure consolidation. The numerous means recommended to this end, the paddings, the plasters, the leathern girdle of Verduc, the complicated apparatus of Lavauguyon, and the still more complicated one of Baillif, act only by circular constriction. In France we have generally adopted the body-bandage, or a towel folded twice or thrice, surrounding the chest and fastened with three or four pins. If this tends to slip down toward the abdomen, it may be kept up by means of bands passing over the shoulders like suspenders.

This apparatus is certainly very simple, but it is not always without its inconveniences. In the first place, it is apt to become loose; Dupuytren therefore added a roller, applied over it, and Boyer substituted for it the *quadriga*, consisting of a figure-of-8 bandage around the shoulders, and spiral turns around the trunk; an apparatus as apt to become relaxed as the body-bandage itself. Again, from its breadth, it is applied with difficulty to women who have large breasts; it must, therefore, in such cases be doubled, and applied below the breasts; but then there is danger of its slipping down. Now one of the essential conditions to be met is, that while the thoracic respiration is impeded the diaphragmatic should be left free, and hence the abdomen must not be compressed.

For all these reasons, I greatly prefer a strip of adhesive plaster, three or four fingers'-breadths wide, long enough to go once and a half around the body, and applied either directly to the skin or over a turn of a roller. A broad band fastened by a buckle would answer the purpose just as well.

[In the Pennsylvania Hospital, and probably in most parts of this country, the local treatment made use of in all cases of fracture of the ribs, is to place strips of adhesive plaster about eight or ten inches

in length and one and a half or two inches wide, parallel with the course of the ribs, and covering a few inches above and below the fracture; each strip overlapping the preceding one by about two-thirds of its width. Compresses may be added to these, if necessary; and they may be renewed whenever they become relaxed. If properly carried out, this plan is quite as efficient as any other in keeping the parts at rest and allaying pain.]

Some precautions are to be observed in thus confining the chest. If the patient, from emaciation, cannot well endure such pressure over the bony prominences, the exposed points should be guarded by compresses or by cotton. In fractures of the lower ribs, the apparatus should not be applied over the ribs themselves, as this cannot be done without making undue pressure on the abdomen. For myself, I make it a general rule not to go below the xiphoid cartilage; it matters little that the bandage does not press directly over the fracture, the immobility of the ribs in the middle necessarily involving that of the rest.

But the most essential point is to regulate the degree of pressure. Fabricius Hildanus wrote to Hagenbach, "*Arcta ligatura quantum sit periculosa in fracturis costarum, alias coram ex me intellexisti.*" J. L. Petit has related a case of simple contusion without fracture, treated by a very tight bandage; he attributes to this bandage, not without probability, an internal inflammation which terminated in suppuration and death. I have seen several surgeons keep a tight bandage around the chest even when symptoms of pneumonia were present; this is an exceedingly dangerous practice.

The only guide for the practitioner as to this point is the persistence of the pain. If it yields to slight pressure, go no further; if the patient feels better for strong constriction, increase it till he is satisfied; if the pain is entirely gone, we may dispense with the bandage without inconvenience; if it persists in spite of the bandage, and much more if it is increased by it, the latter is useless and injurious.

The rule thus given for simple cases, is not less applicable to such as are complicated. Thus in persons with chronic affections of the chest, asthma, bronchitis or phthisis, we should not aggravate this with a view of remedying the external malady. If the fracture gives rise to pain, apply the apparatus moderately tight, letting the patient be the judge. If he feels better, we should continue; if he complains of annoyance, or of suffocation, we should diminish the pressure or even remove the whole apparatus.

It may be however that a man with his chest crushed cannot support the constriction of the ordinary bandage, and yet complains much of the pain of the fracture. Alanson has recommended in such cases a flannel bandage, as constituting a soft and elastic compressor, capable of yielding, and easily accommodating itself to the

alternate movements of the chest. I have sought to obtain immobility of one side only of the chest, with long adhesive strips arranged in a certain way; thus, starting with one strip at about the anterior extremity of the seventh rib on the right side, I brought it round the left half of the chest, up under the left scapula to above the right shoulder; thence a second time round the thorax to the left, to terminate at last at the level of the right iliac crest. The costal respiration was notably hindered on the left side, while it remained entirely free on the right. Perhaps by fastening the arm against the ribs we could gain still more; if not, we must be satisfied with rest in bed, leaving the chest free.

But when the displacement, although apparently slight, gives rise to intense pain, unappeased by the bandage; when the depression of a splinter or of a fragment irritates the lung, and besides the present pain threatens serious visceral inflammation, reduction is indicated, and the question is only as to the choice of means.

I shall only say of cups and drawing plasters, that they are clearly useless. Strong inspirations, or efforts made by the patient under our direction, are the most rational means, and may at least be tried without risk. I have seen a bone-setter who made the patient blow strongly into a bottle, applying his lips around the neck of it; this was nothing but a simple effort. M. Lionet has recently communicated to the *Société de Chirurgie* a plan which has several times been found useful in immediately allaying the pain, viz., squeezing the patient strongly from before backward, so as to depress the sternum; directing him to make an effort at the same time. I have tried this by pushing the patient against a wall, with his back to it, and bearing with my hand on the sternum; and in some cases when no displacement was apparent, I actually succeeded in thus allaying the pain. Probably these fractures were of the internal table; and in my experiments on the dead body, I have seen how such pressure might be useful. In the memoir, previously quoted, I said: "When there is an incomplete fracture of the internal table, with depression of the external one, compression at both ends of the rib diminishes somewhat the depression, but does not entirely efface it; whenever I have sought to gain by increasing the pressure, I have only succeeded in rendering the fracture complete." The effort made at the same time by the patient doubtless aids in disengaging the points of the fragments, entangled in the pleura; but however this may be, it is useful to maintain the reduction by applying compresses to some degree of thickness over the sternum, and surrounding the chest with a strip of lead-plaster; it is the only case in which it seems to me that J. L. Petit's ideas may be properly acted on.

Ravaton succeeded in another way, but still by a sort of effort. A miller, having had a heavy wagon pass over his chest, had three ribs broken, which *touched one another*, says the author, *by their*

angles. Ravaton made him suspend himself by two sticks under his armpits; immediately the pain, which was very severe, ceased entirely, and the ribs assumed their *proper levels.* Ravaton explains this by the tension of the intercostal muscles; but whatever the theory may be, the fact remains.

When considerable depression exists, such means would undoubtedly be quite useless; and if the sternal fragment were driven in, as generally occurs, pressure on the sternum would be positively injurious. I have seen in my experiments on the dead subject that by carefully pressing the fragment which remains in place, till it touches the one which is driven in, the serrations of the one may become interlocked with those of the other,—and then on removing the pressure from the former, its elasticity brings it to its level and at the same time elevates the other. In the living subject a strong effort, conjoined with this manœuvre, aids it; moreover, experience has shown me that it is not even necessary to completely elevate the depressed fragment in order to allay the pain. Doubtless then we give relief by disengaging the points from the tissues. I have published in my *Mémoire* two remarkable instances of success with this method; and since then I have been equally fortunate with it in two other cases.

Lastly, graver conditions may be presented, calling for more energetic measures in order to reduction. Soranus, supposing the pleura to be wounded by the bony point, laid the rib bare by incision, passed in a guard to protect the pleura, and then cut off and removed the sharp ends. Duverney recommends cutting through the intercostal space below the fracture, so as to introduce the finger into the chest and push out the depressed portions. Goulard devised a double hook for the same purpose; Bœttcher proposed the use of the elevator; Callisen, to facilitate the use of the elevator by an incision. But here the plans are more numerous than the cases; I have found no one but Rossi who mentions in one place having had occasion to remove a piece of a rib; and he elsewhere speaks of having removed the posterior extremity of the ninth rib by means of a lever introduced through an incision in the next intercostal space below; he gives no further details. For my own part I have never met with such indications; but I should much prefer using a hook curved like a tenaculum, carefully inserted over the upper border of the rib and carried along its inner face, so as without incision to pry it up as with an elevator.

When we have succeeded in raising up, or in merely disengaging, a depressed portion of a rib, it is important to prevent the displacement from recurring, which would almost certainly involve a return of the pain. Too tight a bandage, or a bad position, may give rise to this. We may try the application of a bandage according to the rules before given; but if we find it useless or injurious, we must

leave it off. The patient should lie as he finds it most convenient; instinct being often a better guide than the surgeon. Experiments on the dead body show us clearly that when the sternal fragment is driven in, lying on the back or on the injured side tends to elevate the posterior fragment, and *vice versâ;* whence we may to some extent judge as to what position will be most suitable. But sometimes also other circumstances occur in the living subject to set aside our preformed ideas; and on the whole the best position is that which causes least pain; only when this is once found it should be maintained by the patient, at least for the first few days.

A simple fracture of the ribs does not generally make rest in bed necessary; a fracture with displacement or with any complication demands it until such symptoms shall have disappeared. I need not here go over the treatment of the visceral inflammations which sometimes complicate these fractures; but a few words must be said concerning traumatic emphysema.

When the emphysema is very marked, the greatest surgical authorities unite in advising incisions into the pleural cavity, in order, they say, to empty the chest. There is no doctrine at once more unfounded and more dangerous; this operation was but once performed by Abernethy, and the patient died from it. When the emphysema is limited to the trunk, nothing need be done; even when affecting the whole body, unless enormous, it will pass off of itself; and lastly, in those extremely rare cases in which it distends the integuments inordinately, a few punctures of the skin with a lancet or trocar suffice to give exit to the excess of air, and to favor the absorption of the rest.*

* Malgaigne, *Du traitement des grands emphysèmes traumatiques; Bull. de Thérapeutique*, June, 1842.

CHAPTER VII.

FRACTURES OF THE STERNO-COSTAL CARTILAGES.*

THESE constitute, so to speak, quite a modern form of injury. Zwinger made it out clearly in the dead subject in 1698; but the fact was entirely forgotten until 1805, when instances were observed simultaneously by Lobstein at Strasbourg and by M. Magendie at Paris.†

These lesions are extremely rare. M. Magendie saw five instances of them in the short space of two years; but this was one of those extraordinary coincidences which sometimes occur in hospitals. Lobstein saw but one case; most surgeons who have mentioned the lesion have likewise seen it but once; for my own part, I have only seen three instances in which it was clearly made out. I find but one reported among the 2328 cases at the Hôtel-Dieu; it is omitted in all the statistics of foreign hospitals; and hitherto has been hardly noticed but by French surgeons. At most we can connect with this subject what Sir A. Cooper says of separation of the ribs from their cartilages by external violence; which is really only one variety of this fracture.

I have observed it in a boy of seventeen and in a man of sixty-three; it occurs therefore both in youth and in quite advanced age. Its causes are very various; such as a direct blow, the passage of a carriage-wheel over the body, or a fall from a height. In these latter cases the fracture may be produced indirectly; in the dead body I have obtained a fracture, quite manifestly indirect, of the cartilage of the fifth rib on the right side, by violent pressure on the sternum.

[M. Broca is quoted in the *Brit. and For. Med.-Chir. Review*, October, 1856, as reporting to the *Société Anatomique* a case in which the sixth, seventh and eighth cartilages were ruptured by muscular action. The patient, a porter, had a sack of peas on his shoulder, when another was suddenly laid upon him. The weight bore him

* Malgaigne, *Recherches sur les fract. des cartil. sterno-costaux; Bull. de Thérapeutique*, April, 1841.

† Lobstein, *Compte rendu à la Faculté de Méd. de Strasbourg*, etc., 1805, p. 24; Magendie, *Mém. sur les fractures des cartilages des côtes; Bibliothèque Médicale*, tome xiv, p. 81.

forward, and in raising himself against it he sustained the injury. The termination of the case is not stated.]

According to the small number of cases known, the cartilage of the eighth rib seems more exposed than any other, and next to this, those immediately above it. I shall mention in connection with fractures of the sternum, one involving the cartilage of the first rib. Most commonly only one cartilage is broken; M. Magendie has seen three, and M. Leudet five, at a time; but these were from severe falls, producing other frightful injuries.

[A case occurred in the summer of 1855, at the Pennsylvania Hospital, in which the sixth and seventh cartilages on the right side were broken entirely through at about an inch from their sternal connections; there was no displacement, and the fracture was not detected until after death. The injury was received by a fall from a wharf, the chest striking on the edge of a boat; the colon was ruptured, and the man died in a few days of peritonitis. The perichondrium was entire in the sixth cartilage, but broken through anteriorly in the seventh.]

The essential peculiarity of this fracture is, that it is always even and perpendicular, never oblique or irregular. Generally there is overlapping; and most commonly the inner or sternal fragment is in front of the other. Hence was derived a theory, ascribing the displacement to the action of the triangularis sterni muscle upon the costal fragment, when unfortunately Delpech met with the opposite displacement; since which M. Velpeau also has seen two such cases.* Delpech suggests that this depends on the seat of the fracture; that when it is close to the sternum, the sternal fragment passes forward, and when close to the rib, the costal fragment does so. To overthrow this opinion it suffices to recall that in rupture of the cartilage even at its place of union with the rib, as described by Sir A. Cooper, the cartilage projected forward. I have made numerous experiments as to this point on the dead subject; and although the results obtained were not always the same, it has yet seemed to me that the displacement is due to the elasticity of the ribs and cartilages more than to any other cause, and that the varieties of it depend mainly on the patient's position. Thus, when the subject is laid on the side on which the cartilages have been divided, the ribs are pushed by the surface on which the thorax lies, so as to make the outer fragment project forward; laying it on the sound side makes the inner fragment prominent; and this form of displacement occurs also when the patient is sitting or standing up.

I repeat, however, experiment gives us sometimes very different results, which it is very hard to explain. Sometimes there is no very perceptible displacement, and a specimen in the Musée Dupuy-

* Velpeau, *Anat. Chirurgicale*, third ed., tome i, p. 355.

tren shows a fracture of this kind consolidated; sometimes the displacement is only in the thickness of the cartilage, whether forward or backward; sometimes, finally, there is actual overlapping, which is here certainly not due to muscular action. I am however very far from denying the influence of the muscles in the living subject, and it would appear to me especially incontestable in one of M. Magendie's cases, in which three cartilages being broken at once, the fragments overlapped *about an inch*, and could not be reduced even after death.

[In the case alluded to as seen by me at the Pennsylvania Hospital, there was no displacement, although the blow causing the injury must have been a very severe one; and from the shape and relations of the cartilage it would really seem impossible for either of the other causes of displacement to affect the fragments to any considerable degree.]

For the rest, this fracture is not of itself serious. The fragments are soon enveloped in a sort of ring of plastic lymph which at length ossifies; it is exactly analogous to provisional callus, but here remains, becoming definitive; and on sawing through one of these fractures longitudinally, we find this ring sending in between the broken ends an osseous lamella which at once unites and separates them. This is, at least, what has been hitherto observed; perhaps in young subjects union may take place differently, and in several experiments on dogs, having cut the cartilages by subcutaneous incision, I found them after fifty days united exteriorly by fibrous or fibro-cartilaginous tissue, without any trace of ossification.

The diagnosis may remain obscure when there is no perceptible displacement. A man aged 23 had had his chest caught between two carriage-poles; one pressed on the left side, at the level of the xiphoid appendix, a little in front of the transverse diameter of the thorax, and the other on the right side, at the same level, and a little posterior to that diameter. Severe pain was at once felt at the costal extremities of the seventh and eighth cartilages on the right side, increased by inspiration and especially by pressure; no displacement was perceptible. I presumed that the cartilages were broken. Here the diagnosis was only a probable one; displacement only could give it some certainty, particularly if one or the other fragment could be depressed at will.

To perform reduction, it sometimes suffices to press upon the projecting fragment; sometimes, when there is overlapping, we must try to remedy it by forcible inspirations. The fragments once being end to end, the only indication is to prevent displacement in their thickness, without which no overlapping can occur. But this most surgeons have regarded as impossible. Sir A. Cooper recommends putting over the fractured cartilage a piece of moistened pasteboard, so as to bear also on the corresponding rib and on the one next to it

on each side; this pasteboard, says he, drying on the chest, assumes the exact form of the parts, hinders them from moving, and offers the same support as a splint in other fractures; it is to be fixed by a flannel bandage around the thorax.

I do not know whether Sir A. Cooper ever used this apparatus; but on the one hand, if the pressure were sufficient, I should dread the occurrence of gangrene of the skin, and on the other I do not see how the fragments are supported during the time required for desiccation. Besides, the relations of the fragments being changed by changes in the position of the body, we must act on both at once, with a force equal in all positions, even in all the motions of respiration. I have succeeded in this with the simple English truss for inguinal hernia. This, as is well known, is formed of an elliptical brace going a little more than half-way round the body, and furnished at its extremities with pads looking toward one another. The posterior pad, acting on the convexity of the ribs, pushes the outer fragment forward; the anterior pad pushes the inner fragment backward; hence we need only make the pads of suitable width and firmness, and the brace being kept in place by the double pressure, there is no need of any circular compression of the chest.

A young man of seventeen struck himself in running, against the balustrade of a staircase, the blow falling at the right side of the sternum, above the xiphoid cartilage. He came to me ten days afterwards; I detected a fracture of the cartilage of the fifth rib on the right side, about an inch from the sternum. When he stood up, the inner fragment presented a slight projection forward, which disappeared under slight pressure or by a full inspiration; it increased when he lay down on his left side, diminished a little when he lay on his back, and diminished still more when he lay on his right side, without however absolutely disappearing. I tried at first a body-bandage, which proved useless; and on the fourteenth day I applied the truss spoken of, previously covering the part with the softened pasteboard recommended by Sir A. Cooper. Some days afterwards, I was obliged to remove this splint, which had already bruised the subjacent skin. I substituted for it a very soft compress; I even fitted to the anterior extremity of the truss an india-rubber air-pad, to lessen the pressure; from that time things went on better; the patient remained up the whole day, lay at night on either side, and when I removed the apparatus on the twentieth day, union was perfect and without the least inequality.

CHAPTER VIII.

FRACTURES OF THE STERNUM.

These fractures are extremely rare; but one case occurred at the Hôtel-Dieu in the course of eleven years; and of 1901 fractures observed in the Middlesex Hospital, Lonsdale noted but two of this bone. Hippocrates does not mention them; they are however spoken of by Celsus, and distinguished by Soranus into two varieties.

Modern observations oblige us to admit other forms. We find in Ploucquet two cases of longitudinal fracture quoted from Kraemer and Meyer; it appears that the latter did not reunite. I have not been able to trace these up; but the following case, given by Barrau, will afford a sufficient idea of this sort of injury.

A mason, aged 60, was thrown from a scaffolding by the falling of the wall at which he was working, and was taken out from the ruins, where several large stones lay upon one side of his chest. The sternum was fractured lengthwise, the fragment on the right side driven in eight or ten lines, the other slightly prominent. To reduce it, Barrau had the right arm drawn aside and backward, and strong pressure made on the middle portion of the true ribs of the same side, from before backward, in order to carry the depressed fragment outward and forward, while on the other side he pressed gently on the salient portion to restore it to its natural level. The reduction was maintained by a tight body-bandage, bearing on two compresses; one of these, wide and thick, was applied over the most prominent part of the ribs on the right side; the other, oblong, over the left portion of the sternum. The patient was cured in six weeks; but it is not stated whether any deformity remained.*

I know of no other instance of longitudinal fracture; whence we may judge of its rarity. I have recently observed another form perhaps still rarer, for I have never seen it mentioned anywhere; it would rank among splintered fractures.

A man of sixty-three was upset by a dray, the wheel of which went up on the left side of his chest, but not getting over the trunk, passed off on to the left arm, which however was uninjured. The next day the man came to the hospital; a quite notable swelling

* Barrau, *Dis. sur les fract. du sternum, Thèse inaug.*, Strasbourg, 1815.

occupied the upper sternal region; and the first piece of this bone, with the cartilage of the second rib on each side, made so marked a prominence in front that I thought I had to deal with a luxation, or with a transverse fracture with overlapping. I tried various manœuvres to accomplish reduction, but in vain; effusion occurred in the pleura; an abscess formed above the fracture, and the patient succumbed on the thirty-third day. At the autopsy, a fracture was found in the semi-ossified cartilage of the first rib on the left side, and also in the second, third and fifth ribs of the same side; these had not been suspected at all. The sternum was broken transversely, at the level of the third intercostal space, the upper fragment being slightly inclined backward; this fracture also had escaped notice. Lastly a fracture, situated above and to the left, detached from the bone as if with a knife, a sort of scale, the base of which reached from the fourchette to the level of the second costal cartilage, comprising all the left sterno-clavicular articulation, and the cutting edge of which was at the anterior face of the bone; the abscess had formed at the seat of this fracture.

Now how was this mistake in diagnosis made? The swelling had something to do with it; again, there was naturally a prominence of the upper part of the sternum; and lastly, the inclination backward of the upper fragment in the transverse fracture had brought still further forward the cartilages of the two second ribs and the articulation of the first two pieces of the sternum, which were not fused.

This is all I have to say touching these fractures. It remains for us to examine transverse fractures of the sternum, which are the most common of all, and the only ones treated of by most authors. In general they are nearly transverse, although this word must not be taken too strictly. In *Figs.* 11 and 12 is seen a fracture of the sternum found by M. Huguier in the body of a woman; *Fig.* 11 shows the edge of the lower fragment in front, by no means regularly transverse; and in *Fig.* 12 a vertical section of the bone shows quite marked inequalities in its thickness. MM. Manoury and Thore saw an oblique fracture so disposed that the lower fragment was bevelled at the expense of its posterior face. In the subject whose history has just been given, the second fracture, nearly transverse at the anterior surface of the bone, had such a direction toward the other surface, that the upper fragment terminated in an angle at the expense of the lower fragment. I have seen another fracture in the living subject, describing a slight curve concave superiorly. These minor varieties are however unimportant.

They are produced by either direct or indirect violence, or even sometimes by muscular action. The direct causes are most frequently such as the caving in of a bank of earth, the passage of a wheel over the chest, the blow of a carriage-pole; in a word, some enormous force. A case related by Duverney shows however that

this fracture may be caused by much slighter violence; it was that of a nine-pin player who, bending forward to watch his ball, fell on a large stone, and was taken up dead, with a fracture of the sternum.

The indirect causes are far more curious to study. These are, first, falls on the back, the principal example of which is quoted from David, but does not properly belong to him, and is rather a luxation of the two first pieces of the bone than a fracture. Sabatier has related another case, recognised as a fracture in an autopsy, although it also was between the two portions of the sternum. But a last case, due to M. Rollande, removes all doubt as to the reality of this cause. A woman aged 63, fell backward from a certain height, struck her back against the edge of a seat, and thus sustained a transverse fracture of the sternum at about its middle.*

Next come very various falls, as on the buttocks, on the feet, on the head. M. Cruveilhier saw a man who, having fallen a distance of twenty feet upon his buttocks, presented no lesions except immense contusion at the part struck, and a fracture of the sternum. In a case reported by M. Cassan, the fracture was produced by a fall from the third story on the feet first, and then on the back. MM. Manoury and Thore have cited an analogous case; it was that of a quarry-man who fell from a height of twelve or fifteen mètres, lighting on his feet first, and by a second impulse striking his back and head. Lastly, I have read in an English journal an account of a young man of twenty-two, admitted in 1832 to St. George's Hospital; the fracture had resulted from his falling head-foremost off a hay-wagon; his head was doubtless flexed forward when he struck the ground, since it had this position after the accident.†

What is the mechanism of these fractures? When caused by falls on the back, they are ascribed to muscular action; and M. Cruveilhier applies the same theory when they result from falls on the buttocks. An attentive study of the facts leads us to different conclusions. In some very rare cases, the patient having fallen on the back, the fracture occurs without overlapping, perhaps even with slight separation of the fragments; it appears that it is in fact due to forcible flexion backward of the trunk, subjecting the sternum to violent distension; only it may be doubted whether the rupture is actually caused by the muscles pulling in opposite directions, or by the forcible separation of the upper from the lower ribs, carrying with them their respective portions of the sternum. But in the majority of cases, on the contrary, the fracture results from forcible flexion forward of the trunk, or at least from a shock tending to approxi-

* Sabatier, *Mém. sur la fract. du sternum; Mém. de l'Institut*, an vii, tome ii. p. 115: Rollande. *Bulletin de Thérapeutique*, tome vi, p. 288.

† Cruveilhier, *Bull. de la Soc. Anatomique*, June, 1826; Cassan, *Archives de Médecine*, January, 1827; Manoury et Thore, *Gaz. Médicale*, 1842, p. 361; *Medico-Chir. Review*, 1832, vol. xx, p. 536.

mate the two ends of the sternum. This was manifest in the patient who fell with his head bent forward. In M. Rollande's case, the blow, although falling upon the spine of the last dorsal vertebra, had certainly induced flexion forward, since the upper fragment of the sternum was driven in behind the other, and the head was bent forward on the chest.

Thus, in fractures by counter-stroke, flexion of the head and overlapping of the fragments indicate a fracture by flexion forward of the trunk, while want of overlapping, or separation of the fragments, are peculiar to fractures by flexion backward. Fractures arising purely from muscular action range themselves in this latter category by their mechanism as well as by their phenomena.

Chaussier saw two such cases from efforts in child-birth, in primiparæ twenty-four or twenty-five years of age; both, at the moment of the rupture, had the head thrown strongly backward, and were resting on the arms and heels. In one the fragments retained their place; in the other they were slightly separated. [A case occurring under exactly the same mechanical conditions as those just described may be found in *Hays' Am. Journ. of Med. Sc.* for July, 1858, (p. 272,) quoted from an Italian journal; it concerned the upper piece of the bone, and terminated in recovery. Another is there alluded to, as having been observed in France, but with a fatal result.] The throwing back of the head occurred in a case of another kind, related by M. Faget, professor in Mexico. A mountebank, displaying his strength in a public place, had leaned backward to raise up with his teeth and hands a considerable weight; all at once he felt severe pain in the sternal region, and fell over with a fracture of that bone.*

There is, however, a remarkable peculiarity in these instances: all three of them were seated above the articulation of the first piece of the sternum with the second. I do not know whether it would be so in fractures from falls with the trunk bent backward; the cases are not given precisely enough for us to judge, and the point demands further investigation.

We must not forget another kind of fracture by muscular action, which would be produced by sudden contraction of the diaphragm, and thus would be analogous to certain fractures of the ribs, before alluded to. I know of but one such case. A locksmith, aged 32, suffered from scirrhus of the stomach, causing frequent vomiting. One day he complained of pain in the sternal region, the cause of which could not at first be imagined; afterwards a transverse fracture was detected in the upper third of the sternum, and the autopsy verified this diagnosis. The bone seemed diseased an inch below the

* Chaussier, *Revue Médicale*, 1827, tome iv, p. 260; Roger Dubos, *Mal. du sternum*, Thèse inaug., Paris, 1835.

fracture, but sound at the precise seat of it.* It may be seen that from its seat this fracture would resemble those induced by flexion of the trunk.

All fractures by counter-stroke or by muscular action are simple, and divide the sternum into two fragments only. Direct causes sometimes produce single fractures likewise; but they frequently break the bone into splinters; or perhaps to the main fracture are added fissures of greater or less extent; or lastly, the bone may be broken at two different points. Duverney saw a fracture with splinters, caused by falling on a stone; Pluto had occasion to treat one with three splinters, from a bayonet wound; La Martinière one with four splinters, a ball having passed back of the bone, etc.† On the other hand, there is in the Musée Dupuytren a transverse fracture with a fissure two or three centimètres long, limited to the outer table; and I have before me an analogous specimen, except that the fissure occupies the whole thickness of the bone. As to fractures dividing the sternum at two points, I know of no other instance than the one related above.

Quite often, also, fracture of the sternum is complicated with fractures of other bones. In falls on the back it is the vertebræ, and especially their spinous processes, which are found broken; in cases of direct violence it is the costal cartilages, or the ribs; not to speak of other complications.

It will readily be understood that fractures from direct violence cannot have a seat so well-defined as others. It is, however, remarkable that they have never been seen to affect the upper piece of the bone; and the lowest piece seems likewise exempt. I saw in 1843, at the Hôpital St. Antoine, a marble-cutter, aged 43, who ten years before had had the sternum broken by a blow from a carriage-pole; the fracture was seated on a level with the upper edge of the cartilage of the fifth rib; I know of no other instance of a fracture situated so low down.

The symptoms in every fracture of the sternum are at first severe pain at the seat of the injury; one of Chaussier's patients heard at the same time a crack which made her say that something had probably given way in her chest. This pain is increased by pressure, or by coughing, sometimes even by the mere effect of ordinary costal respiration; it diminishes when the ribs and sternum are kept at rest; sometimes, lastly, almost immediately after the accident it disappears, and does not recur. When the fracture is the result of a direct blow, the integuments offer generally traces of contusion, and

* *Gazette des Hôpitaux*, March 20, 1830.

† Pluto, *Journal de Méd. Milit.*, par Dehorne, tome i; and *Dict. des Sciences Médicales*, art. *Sternum*; La Martinière, *Mém. sur l'opér. du trépan au sternum*; *Acad. de Chirurgie*, tome 4, p. 545.

ecchymosis ensues either at once or within a few days; but this is not at all constant. We should expect, also, the occurrence of more or less swelling of the part; and the inflammation sometimes runs on to suppuration, either at the seat of fracture, or behind it in the mediastinum.

Displacement brings with it other evidences, the clearer in proportion as it is more marked. It may indeed be very slight, imperceptible in the living subject, as in the case I have related; or it may be more pronounced, one of the fragments projecting by as much as half its thickness; this is what is seen in *Fig.* 12; or the displacement in the direction of the thickness may be complete, and more or less overlapping may be conjoined with it. But what is extremely remarkable is, that it is almost always the lower fragment which projects forward; I know of but one instance of the contrary; it will be seen that then there was overlapping to an almost incredible degree. A man more than sixty years old was set upon and beaten with fists, and afterwards thrown into a hole thirty feet in depth. He fell on his back, and when examined was found to have a transverse fracture of the sternum at the junction of the first and second pieces, the latter being driven behind the former. Reduction was impossible; the patient died on the eighth day. At the autopsy, Sabatier found the sternum fractured at the point mentioned, and the lower portion of the bone *not only driven in, but also engaged behind the upper one to the extent of twenty-eight millimètres.*

It is remarkable that such shortening of the anterior wall of the chest so rarely induces bending of the trunk and of the head; I have only twice found flexion forward of the head mentioned.

When the fracture is simple and without displacement, crepitus is quite frequently wanting; sometimes we may obtain it by pressing alternately on the fragments; lastly, there are certain cases in which it is produced without any effort, by the mere movement of respiration. Mesnier, in 1702, observed this phenomenon, but in an old fracture, the fragments being carious and bathed in pus. Meek detected it in 1764, in a case of recent fracture, and with attending circumstances worth relating. The patient was an old man of seventy-four, who had had the sternum and the three lower true ribs on the right side broken by the passage of a carriage-wheel over them. The fragments rubbed on one another in respiration to such an extent that crepitation was audible ten paces off; on applying the hand to the chest, the lower fragment was felt to be pushed forward at each inspiration and drawn back at each expiration, so as to pass by the edge of the upper fragment in each direction; the latter remained nearly motionless. The patient being unable to endure any apparatus, this noise could be heard for three weeks; after which it ceased, and the fracture became so firmly united that its seat could

not be distinguished.* Sabatier has related an almost exactly similar case; so much so as to seem as if copied from the preceding one.

Such are the symptoms of the fracture itself; but when it is produced by a direct cause, other symptoms due to lesions of subjacent parts often come in as complications. Russel, Flajani, and Dupuytren have seen fractures of the sternum attended with emphysema.† Frequently patients are troubled with dyspnœa and spitting of blood, denoting more or less grave injury of the lungs. Lastly, when one of the fragments is driven in, the heart itself may be wounded. J. L. Petit found in an autopsy the heart merely compressed; but Dupuytren saw the right ventricle torn in two-thirds of its thickness, and Duverney relates two cases of complete rupture of the heart. Lesion of the internal mammary arteries has been dreaded also; but hitherto I know of no instance of it.

Apart from these complications, fractures of the sternum generally terminate favorably. One month would seem to be sufficient for consolidation; in one case the apparatus was removed on the twenty-third day without any inconvenience; most surgeons have kept it on for about six weeks. It is but rarely that we can succeed in entirely correcting the displacement; such cases are however related, among which may be specially noted those of Meek and Sabatier. But even a considerable displacement does not of itself entail any serious inconvenience. My stone-cutter, in whom the upper fragment was driven in five or six millimètres, attended to his business for ten years without its giving him any trouble. M. Huguier's patient, with a displacement of which *Fig.* 12 gives an exact idea, was in no way incommoded by it.

Must we not, however, admit there are exceptions? "I have remarked," says J. L. Petit, "that a man was subject to a dry cough, with palpitation of the heart and difficulty of breathing, who had had the sternum driven in." Duverney speaks of a patient who was cured in six weeks, who, however, still continued in ill-health; Sabatier's patient had ever afterwards some difficulty in breathing. But the complications entirely account for these results. Duverney's patient had two cartilages luxated, his symptoms had yielded only to several bleedings, and he was an octogenarian; Sabatier's, from the effect of the external violence, had vomited blood; these were circumstances which could not but influence the results of their cases.

The diagnosis is far from being always easy. In one of the cases observed by Chaussier, the fracture was only recognised on the sixth

* Meek, *Essays and Obs., Physical and Literary, of the Edinburgh Society*, vol. iii, p. 535. Mesnier's case is in La Martinière's memoir, already cited, p. 550.

† Russel, *Obs. et recherches des méd. de Londres*, tr. into Fr., tome i, p. 287; Flajani, *Collezione d'Osservazioni*, tome iii, p. 214; Dupuytren, *Leçons Orales*, tome ii, p. 215.

day; in the other, only at the autopsy. This is explained by the nature of the causes, as in the patient whose fracture was the result of vomiting, and in whom it likewise remained undetected. But in Flajani's case, the fracture was direct; the upper fragment was driven in, and yet the emphysema prevented its discovery till after death. For my own part, as has been seen, I fell into a double error; I overlooked a second fracture, from being preoccupied with the first; and in this I was deceived as to its seat and direction.

We must, then, so long as there remains any emphysema or swelling, abstain from affirming or denying the existence of fracture; and if this is made evident by crepitation, we must still avoid pronouncing too soon as to its nature, and even as to the presence or absence of displacement. The sternum often presents congenital or accidental depressions which would closely simulate those caused by violence; only if there is notable overlapping, besides the depression in the sternum, we should have a nearly pathognomonic sign, to wit, the narrowing of the intercostal space corresponding to the fracture.

The prognosis is generally simple and favorable when the fracture is a simple one; its gravity depends on that of the complications. Still, even in the simplest fractures, the danger of suppuration merits special attention here; among the few cases known, it occurred in five, viz., in Mesnier's patient, in Chaussier's two women, in the man whose fracture resulted from vomiting, and in my own patient.

The indications for treatment vary according as there is or is not displacement. When the fragments remain in contact, we have only to keep the thorax at rest by means of a body-bandage, or better still by a wide strip of diachylon or lead-plaster. If the bandage cannot be endured, the patient should be kept on his back in bed, with his head low rather than high. For the rest, exactly the same rules apply here as in fractures of the ribs, as to the degree of pressure, the application of the bandage, and even the position of the patient. In the two cases, so nearly similar, of Meek and Sabatier, the patients experienced such difficulty of breathing as that no pressure could be borne; they could not even lie down for any time, and for eight days they had to be supported in the sitting posture, either in bed or on a sofa, bending forward, and with the head resting on a chair well garnished with pillows.

When the depression is simple, and without overlapping, the idea which first occurs is to press on the projecting fragment, to push it in to the level of the other; we shall presently see that it has been proposed also to act on the fragment driven in, so as to raise it up. Unhappily the displacement, maintained at once by the intercostal muscles and by the differing elasticity of the ribs attached to the two fragments, does not always yield so readily as one would be led to suppose. Besides, when there is overlapping also, some kind of extension must be made on the sternum, and this bone affords of

itself no purchase. It has therefore been sought to act on the two fragments by means of the ribs, the shoulders, the head, and the spine.

Paulus Ægineta, doubtless following Soranus, put a cushion under the patient's back, drew the shoulders backward,—acting thus through the clavicles on the upper fragment,—and pressed at the same time on the ribs of both sides; this would tend to open the arc which they describe, and to carry their sternal extremity forward. A. Paré says he once succeeded by this plan. In case of failure, Duverney adopted another method; he laid the patient on his side, putting something hard beneath his ribs, and then pressed on the ribs of the opposite side, an assistant at the same time pushing inward upon the spine. Later surgeons neglected, perhaps too much, the idea of acting upon the ribs; Aurran, placing a bolster under the back, pressed at once on the chin and on the pubis, so as to curve the trunk backward; Monteggia sought to draw the shoulders back, while he pushed against the spine with his knee; in the patient at St. George's Hospital, throwing the head back strongly was sufficient to obtain complete reduction. But here I have a remark of some importance to make.

Judging from the few cases published, reduction should be quite easy; its maintenance alone should present any difficulty. I must say, however, that I have seen a recent luxation of the first piece of the sternum on the second, a lesion entirely comparable to a transverse fracture, which resisted all my efforts; and in the only case in which the lower fragment was driven in behind the upper, reduction was likewise impossible. Perhaps overlapping constitutes more of an obstacle than mere depression; perhaps also the tension of the skin over the sternum during the operative proceedings has deceived surgeons, making them too readily believe the reduction complete; however it may be, it must at least be admitted that there are fractures with depression which are quite unmanageable, and for which various operations have been devised.

J. B. Verduc was the first to propose making an incision through the integuments, and inserting an elevator into the depressed fragment, in order to draw it out to the level of the other. J. L. Petit advises the use of the elevator and of the trepan. Delpech thinks it would suffice to cut with a lenticular knife a portion of the anterior fragment. Quite recently M. Nelaton has suggested that it might be practicable to introduce, through a narrow opening alongside of the bone, a blunt hook to raise the depressed fragment. I had myself had another idea, which was to carry through the skin to the end of the anterior fragment a point, by means of which it could be pushed either down or up to the level of the other; but the sternum is too soft in texture, and the instrument penetrates it too easily.

Of all these means, the elevator would seem the simplest and the least dangerous; but there are two circumstances which should make

the surgeon cautious, not only as to operations of this kind, but also as to the too free use of ordinary methods of reduction. The first is the danger of suppuration, alluded to above, and the second is the difficulty of keeping up the reduction when obtained.

La Martinière has cited a case in which the elevator was employed; but the reduction so made was so insecure that it was deemed proper to leave the instrument in place, fitting a stick to it like a lever, to keep the fragments in position; but death occurred too soon for us to judge of the success of this singular plan.

Richerand had to deal with a depression of the upper fragment to the extent of a few lines merely; he applied over the lower one thick compresses, fixed by a very tight body-bandage and roller. The apparatus was renewed whenever it became loose; at each dressing an assistant pressed strongly on the lower fragment, so as to keep it at the level of the other, and this was kept up for forty days; but in spite of all his care there remained a hollow, and a projection of some lines. The surgeons of St. George's Hospital took much more minute precautions; they kept their patient with his head as far back as possible, his shoulders drawn back by a figure-of-8 bandage round both of them; a pad was applied over the projection, and supported by a roller around the chest. The displacement was thus diminished, but not entirely overcome. In a patient treated at the Hôpital Beaujon, in 1829, the fragments were easily reduced by simple pressure; but it was so hard to keep them in contact that the bandage had to be tightened daily.* Lastly, in M. Rollande's case, the patient was paraplegic, and certainly remained as completely at rest as possible; yet the fragments, restored at first to their place, became somewhat deranged afterwards.

I think therefore that although it is proper to attempt reduction, it is wrong to persist in endeavoring to make it complete. As to the means of retention, unless the displacement tends strongly to recur, the body-bandage, or rest in bed, may be sufficient; if not, we may exert moderate pressure over the anterior fragment by means of thick compresses fixed with a strip of diachylon, the patient having a cushion under his back so as to bend the trunk backward, and his head being at least as low as his chest. The position of the head is especially important; several times displacement has been seen to recur from its being inclined forward. Perhaps we should succeed still better by fixing the shoulders upward and backward with Brasdor's corset, or with one of the apparatuses modeled upon it, of which we shall speak when on the subject of fractures of the clavicle.

J. L. Petit and La Martinière, and after them Boyer, recommend trepanning, so as to give an issue to the blood effused behind the frac-

* *Journal des Progrès*, 1830, tome ii, p. 258.

ture. It is not worth while to refute this idea. The sternum should not be thus meddled with unless pus is collected behind it, and the bone itself is carious. In one case of gunshot fracture, La Martinière exposed the bone, and by means of the elevator removed four splinters, amounting in size to about that of a crown-piece. Pluto, in an analogous case, limited himself to removing one splinter and elevating the rest; long before this, Mesnier had applied the trepan to destroy a caries of the fragments, and thus opened an abscess behind them. These three patients all finally recovered; and in analogous circumstances the same plan should be adopted.

I say nothing of visceral inflammations, which should be energetically combated, but the discussion of which does not properly belong here.

CHAPTER IX.

FRACTURES OF THE CLAVICLE.

I PASS from fractures of the sternum directly to those of the clavicle, partly on account of the anatomical relations of the two bones, but mainly because they present, as was before said, some indications in common.

These fractures may without hesitation be ranked among the most frequent, since of 2358 fractures they numbered 228. They occur indifferently in all seasons; I find but three more in the summer than in the winter months. But sex and age exert an influence not to be passed over.

Among the 228 cases, only fifty-eight were women;—about one-quarter. This proportion remains nearly the same for the period of life between fifteen and sixty-five years; but after this, singularly enough, the clavicle seems to be oftener broken in women than in men; in fact, eleven out of eighteen cases were women. I have no precise data whereby to establish the proportion of the sexes in early life; all that I can say is that at the Hôpital des Enfants there are more fractured clavicles in boys than in girls.

As to ages, before fifteen our table shows but six fractures, and over sixty years only thirty-one. But it must be observed that at the Hôtel-Dieu children are only received in exceptional cases; and at the Hôpital des Enfants fracture of the clavicle is one of the most common of all fractures. The clearest result from these figures is therefore that it is comparatively rare in old age, and its frequency in youth and in adult age accords very well with its equal frequency in summer and in winter.

The determining causes likewise show the reason of these statistical results. Sometimes they are direct blows, the fall of a beam, a blow with a stick, more rarely a fall in which the clavicle strikes against some object; now men are more exposed to such accidents than women are, and adults more than old people.

Sometimes, and perhaps more frequently, the causes are indirect, as a fall on the hand or on the elbow, and the most frequent cause of all is falling upon the shoulder. Now as I shall show hereafter, falls on the wrist are more apt in women to cause fracture of the

lower end of the radius, and in old age falls on the shoulder most commonly occasion fracture of the cervix humeri.

The clavicle may be broken at any point in its extent. Is there any relation between the nature of the cause, and the seat of the fracture? M. Thouverey has made some experiments in order to solve this problem;* but these attempts, made on the skeleton and under entirely artificial conditions, cannot even furnish the commencement of a demonstration. They must be repeated upon whole subjects; yet still, the clavicle is acted on by so many muscles which in the living subject vary its position in a manner which cannot be imitated after death, that such experiments deserve but limited confidence.

I shall discuss successively: (1) fractures of the body of the bone; (2) fractures of its sternal extremity; (3) fractures of the acromial or scapular extremity; (4) fractures of both clavicles at once.

§ I.—*Of Fractures of the Body of the Clavicle.*

These fractures, beyond comparison the most frequent of any in this bone, engaged almost exclusively the attention of surgeons down to the seventeenth century; and for them especially all the dressings were invented.

They may be produced by direct or indirect causes. The mechanism of the first needs no explanation; for the others, as in falls on the elbow or on the hand, but more particularly in falls on the point of the shoulder, it has been said that the bone, being pressed between the ground at one end and the weight of the body acting through the sternum on the other, tends to bend at its point of greatest curvature, so that the fracture occurs either at the middle or in the outer third of the bone. This is a theoretical view, sometimes doubtless confirmed practically, but often contradicted by the different seat or direction of the fracture. Thus there is seen in *Fig.* 17 a fracture caused by a fall from a second story; it is certainly indirect; everything would lead us to suppose that the fall took effect on the point of the shoulder; and yet the extreme obliquity of the fracture forbids our assuming here any increase of the normal curvature.

Other circumstances besides falls may also give rise to indirect fractures. Nicod has related the case of an old woman who broke her clavicle in pushing forcibly the door of a cupboard;† which may be compared with the case of fracture by falling on the hand. I have seen an incomplete fracture of the clavicle resulting from the pressure of a burden which slipped from the shoulder down on to the

* Thouverey, *Thèse inaug.*, Paris, 1827, No. 243.

† Nicod, *Annuaire Médico-Chir. des Hôpitaux*, 1819, p. 498.

arm, and thus pulling downward on the outer end of the bone, bent and broke it at about the middle.

Lastly, a cause perhaps rarer than any other is muscular action. In the *Gazette des Hôpitaux*,* an account has been given of a young and robust woman, who had never had syphilis or taken mercury, and who drawing her husband toward her while in bed, broke the right clavicle. I have myself seen recently, and as it were one after another, two cases of the same kind. November 8, 1844, there entered my wards a laborer, aged 41, who in heaving some building-stones upward had felt a sudden pain and crackling, and was found to have a fracture a little outside of the middle of the right clavicle. Fifteen days later there came in a young man of eighteen, who having raised a heavy shovelful of rubbish, and making a great effort to throw it into his cart, heard a crack in his shoulder, and dropped his shovel; he had broken the right clavicle in its inner third. I would observe that in both these cases the fragments remained connected, and made an angle salient anteriorly.

Fracture of the body of the clavicle presents notable varieties, which are not without relation to its different causes. Thus falls on the shoulder most commonly produce oblique fractures in adults, and serrated in children; direct blows give rise to serrated, splintered, or multiple fractures.

Lastly, in young subjects, incomplete fractures have sometimes been observed. Johnson has quoted two such cases. The one which I saw, which was mentioned above, occurred in a young man of fifteen, healthy and of good constitution; the fragments formed an angle directly upward, and in view of the patient's age I at first thought I had to deal with a complete fracture. But the impossibility of correcting the angle, even with considerable pressure, soon made me change my mind; and bearing down on it still more forcibly, I heard a dry crack announcing the completion of the rupture; at the same time the angle yielded and disappeared beneath my fingers. An analogous case may be found in Dupuytren's *Leçons*. A boy of fifteen fell on the outer and anterior part of the right shoulder; there was soon severe pain, and impossibility, from the pain, of moving the arm; Dupuytren found the clavicle curved forward. On the third day, Pelletan sought to remedy the curvature by pressing upon it; at the first attempt a cracking was heard by many of the students, and the fracture was then recognised.† Notwithstanding Dupuytren's opinion, I should see in this case all the characters of fracture not at first complete, but made so by the surgeon.

But complete serrated fracture, the fragments remaining in contact, is much more common, especially in children, and should not be

* October 5, 1844.

† Dupuytren, *Leçons Orales*, tome i, p. 115.

confounded with the preceding form; I have already said that Sanson (See p. 66) committed this error. Sometimes then the fragments are bent at an angle; again there may be no displacement; Monteggia saw some of these fractures which were undetected until their cure was in progress; he even saw some in which consolidation was complete, the callus alone betraying their existence. The same thing may occur in adults: Brunninghausen relates the case of a joiner, who got a fall, striking the clavicle against a post. There was much contusion, but no displacement or crepitation; and Brunninghausen and Siebold discovered no sign of fracture. The man went back to his work; but three days afterwards he returned, his pain having increased, and this time the injury was recognised.* Amesbury saw such a fracture treated as a mere contusion.

Serrated fractures may however be attended by the most marked displacement; generally then one or more of the serrations are broken off, constituting so many splinters.

Oblique fractures vary in the first place according to the degree of obliquity. *Fig.* 17 presents a very considerable obliquity, slight however if we believe Ravaton's statement, that he saw a fracture extending nearly two inches along the bone. But it is the direction of the obliquity which is chiefly important, by necessitating, so to speak, the direction of the displacement. Generally the line is from without inward and from before backward; sometimes inward and forward; sometimes, but rarely, in exactly opposite directions.

Multiple fractures differ as to their number as well as their seat, in each case. *Fig.* 20 shows one fracture at the acromial, and another at the sternal end of the same clavicle; in such a case each one would be like a single fracture. But if two or three occur together in the body of the bone, the middle fragment, very short and almost completely detached from the soft parts, sometimes turns round among the rest; a sort of displacement impossible to overcome. I have seen in a little girl a double fracture in which the middle fragment, about two centimètres in length, was situated vertically between the two others; all my attempts to disengage it were futile. M. Guersant, to whom I sent it at the Hôpital des Enfants, was not more fortunate; callus was deposited, but with notable deformity.

In fracture with overlapping, which is most commonly the case, the symptoms are numerous and characteristic. At the instant of its occurrence, the patient feels severe local pain, and sometimes hears a crack as the bone gives way; almost instantly the movements of the arm and shoulder become either impossible or very difficult, on account of the pain; the shoulder, dragged by the weight of the

* Brunninghausen, *De la fracture de la clavicule; Biblioth. Germanique*, tome ii, p. 403.

arm, falls downward, inward and forward; the forearm hangs in a state of marked pronation; to avoid at once the stretching of the cervical muscles and the pricking of the tissues by the points of the fragments, the patient inclines the head and body toward the fracture, turning the face a little the other way; and sometimes he carefully supports the forearm with the other hand. The clavicular region being exposed, we see the point of the shoulder lowered, carried in toward the sternum, and more prominent forward than usual; with the finger, and very often with the eye, the depression of the outer fragment, and the prominence and overlapping of the inner, may be recognised. The two fragments can be moved one on the other; they can be replaced by carrying the shoulder upward, outward and backward; and all these movements give rise to a more or less marked crepitus.

Among these symptoms there are two which demand special attention; the difficulty of movement, and the displacement.

"The patient," says Boyer, "cannot raise the arm and carry it forward; he is particularly incapable of the movement of circumduction by which the hand is carried to the front of the head or to the shoulder of the opposite side; and if directed to put his hand to his head, he executes the movement partly by flexing the forearm, partly by inclining the trunk and head toward the wrist." This description is far from being always exact. "Every one knows," says M. Gerdy, "that the arm can be easily carried forward and backward; it is therefore only forced abduction and elevation, such as take place when the hand is put to the head, which are hindered." Bichat explained the loss of these movements by the very fact of the rupture of the bone, putting the patient, so to speak, among the non-claviculated animals. M. Gerdy has disposed of this theory; and it suffices at once to consider that cats, although destitute of clavicles, pass their paws over their heads with great ease. But the study of this phenomenon in man plainly shows the chief cause, as pointed out by Brasdor, to be nothing more or less than the pain. This is so true, that a patient who at first moved the arm only with great difficulty, can raise the hand to the top of the head with ease as soon as the pain subsides; and that if the fracture is transverse, the movements are almost completely restored before the occurrence of consolidation. Moreover, it is not rare to see patients able from the very first day to carry the hand to the head, when the fracture is attended with but slight pain.* The most striking case of this kind is certainly that observed by M. Ferrus in 1831; it was in an insane man whose sensibility was almost entirely destroyed. He fractured his clavicle, and the fragments were considerably displaced; and yet

* Gerdy, *Obs. et Réflex. sur les fract. de la clavicule*, etc.; *Archives de Médecine*, 1834, tome vi, p. 356.

he raised the arm and moved it in all directions with apparently as much facility as he did that of the other side.*

For the rest, the pain alone does not seem to me to explain the hindrance of certain movements, and the amount of overlapping has probably something to do with it also. I should say indeed on this point that Bichat's theory is not to be absolutely rejected; and that a broken clavicle, with marked displacement, actually does assimilate the patient to the non-claviculated animals. These latter can carry the paw to the head, but cannot carry it thence outward, and especially backward; likewise in our patients, the elevation of the arm backward and outward, and movement of the hand backward are impossible except within certain limits.

The displacement varies with the direction of the fracture. The most frequent is undoubtedly that in which the outer fragment is drawn downward; and this comprises three varieties. Sometimes the fragment descends equally in its whole extent, and in a plane parallel to the sternal fragment; *Fig.* 19 will illustrate this. Sometimes the fragment, although carried entirely below the other, is more depressed at its acromial end; this may be clearly seen in *Fig.* 21, taken from a specimen in the Musée Dupuytren. Lastly, when the fragments are still connected, the outer one quite often inclines downward by its acromial end, making with the inner one an angle salient upward; Delpech gives a case of this kind; I have myself cited one in my *Anatomie Chirurgicale*, and have since met with another.

There are some fractures in which the outer fragment remains on a plane above that of the other. This curious variety was pointed out by Hippocrates; Desault has published an instance of it, and the first broken clavicle I had occasion to treat was of just this kind. The case is very rare; most of the classical writers have passed it over in silence, and I have myself never seen any case but the one alluded to.

Overlapping comes second in the order of frequency. It is wanting in the majority of serrated fractures, especially in young subjects, and varies extremely in degree. Sometimes it is limited to a few millimètres; but in *Fig.* 19 it was more than two centimètres; and in the Musée Dupuytren there is a clavicle (No. 60) which has lost nearly one-third of its length by overlapping.

In the third form of displacement the outer fragment is generally carried more or less back from the inner, while its acromial extremity is on the contrary carried forward. In *Figs.* 19 and 21, the inner fragment projects considerably forward, from the outer one retiring backward; and so also in *Fig.* 17, where the obliquity inward and backward makes such a result as it were necessary. It is

* *Gazette des Hôpitaux*, Jan. 18, 1831.

in such cases especially that the shoulder is carried forward; and the two fragments form an angle salient posteriorly.

If on the contrary the fracture is oblique inward and forward, the outer fragment almost necessarily rests in front of the other. Of this an example is seen in *Fig.* 20; the shoulder cannot then be carried forward but with great difficulty; the two fragments overlap without forming any angle, or perhaps this angle may be salient forward, as seen in the figure. Sometimes also in serrated fractures the fragments remaining in contact make a very marked angle in front, of which I have before quoted two instances.

Finally, M. Grout was the first to point out a fourth form of displacement, in virtue of which the upper face of the acromial fragment looks forward, its posterior edge being upward; the specimens represented in *Figs.* 18 and 21 offer this kind of partial rotation.* But it would seem to be entirely artificial, and due to an excessive elevation of the shoulder in the course of the treatment.

All these displacements are generally described as if they concerned only the external fragment; it must however be borne in mind that the inner one is also movable; that in virtue of the different obliquity of the fracture, and of the overlapping, it is itself pushed in the opposite direction from the outer one; that the action of part of the sterno-cleido mastoid muscle tends to draw it upward, and sometimes holds it with extraordinary force.

This is not all; even when it is put in proper relation to the other fragment, it is liable to be again displaced by the least movement of the head, of the trunk, or even of the opposite arm. M. Guérin (de Vannes) has particularly called attention to this mobility of the inner fragment; he has proved it both in the living and dead subject; when the fracture was most perfectly reduced, it sufficed for the patient to turn his head or move the arm on the sound side to derange the fragments and even produce very distinct crepitus.†

The course of these fractures is generally very simple; the clavicle is a spongy bone, and unites with great rapidity. Hippocrates has fixed the duration of the treatment at fourteen to twenty days, and consolidation has indeed been occasionally seen at the end of this time. But these are exceptions upon which it would be folly to base any calculations, except in children, and in fractures without any displacement whatever. Avicenna laid down as the general rule a

* It may perhaps be conceived, by considering on the one hand the normal curvatures of the clavicle, and on the other hand the displacements, so very complex, to which its fragments are subjected, how difficult it is to represent them with the pencil. I have had other drawings made than those from *Fig.* 13 to *Fig.* 20, inclusive; these have been as many as three times re-attempted under different aspects; and yet they are far from giving an exact idea of the specimens which I had before me.

† *Archives Gén. de Médecine*, May, 1845.

term of thirty days; and when the fracture is very oblique or the displacement very marked, according to the experience of Delpech the apparatus should be kept on until the sixtieth day, or even later.

In some cases the fragments do not become united, especially if they have been widely separated, but sometimes also when they have been kept in contact; of this a curious instance is shown in *Fig.* 18. It is to be regretted that we have no information as to the origin of this specimen, which was given to the Musée Dupuytren by Laënnec. It can only be affirmed that the fracture was of ancient date. On examining it with care, we see that the sternal fragment is carried upward and forward, and the acromial upward and backward, with very marked overlapping. The fragments are connected in this position by a false joint, and it would seem that the shoulder, thus badly supported, has drawn the acromial fragment strongly downward, so as to make it form with the other an angle salient upward and forward; then by the effect of time and of the pressure of the integuments, not only has this angle been rounded off, but the sternal fragment has actually bent so as to assume an unnatural curve, so that it would be in vain to rectify the relative position of the fragments; the natural form of the bone could never be restored. The specimen has been sketched with the angle downward which naturally is upward, in order clearly to display this curious secondary curve.

It may be said in this case, that a true diarthrosis was formed; another instance is reported by M. A. Petit.* It is much more common to see the fragments entirely isolated, free as it were among the tissues. Conditions so diverse involve consequences no less variable. M. Gerdy has related the case of an old cuirassier, who had an ununited fracture of the right clavicle; at each movement of any extent, a crackling was heard, showing that the two fragments rubbed upon one another; the patient, however, who was enrolled among the gendarmerie, fulfilled his duties without difficulty. M. Velpeau saw equally free motion in the case of a market porter.† But it is otherwise when the broken ends are free. Brasdor saw a man who had been unable to endure the bandage, and whose fracture was ununited. "He could raise his hand to his head and take off his hat. To do this, he first carried the arm backward; then he raised the hand as high as his head, and brought it over by a movement of circumduction." We see that these were not natural motions; but this is not all; "it was observed," says Brasdor, "that he was uncertain in these movements, executing them unequally and feebly." I shall relate a still more striking instance when on the subject of fractures of both clavicles at once.

* M. A. Petit, *Coll. d'Observations Cliniques*, p. 297.
† Gorré, *Thèse inaug.*, Paris, 1835, No. 218.

I say nothing of the complications enumerated by some writers, which consist mainly in lesions of the subjacent vessels and nerves; in spite of the proximity of these, I do not know that they have ever been injured when the clavicle has been broken.

The diagnosis is generally very easy. Bichat states that he several times heard Desault establish his diagnosis merely upon the attitude of the patient on entering the amphitheatre. This would be presumptive evidence, but nothing more, since other lesions of the shoulder may give rise to the same. The difficulty of carrying the hand to the head is no more significant; but displacement and crepitation place the matter beyond doubt.

Crepitus is often wanting in serrated fractures; we must then look for the angle formed by the two fragments. If they retain their normal direction, but if the violence sustained, the pain at one point in the bone, and the local swelling, induce us to suspect fracture, we may first try to bend the bone by pressing upon the probable seat of injury with the thumbs; or, by moving the shoulder in various directions, we may seek to cause angular deformity. This, however, must only be resorted to in very recent fractures; and sometimes, however recent the fracture may be, the diagnosis is singularly doubtful.

A young man of twenty-two fell from a horse, striking the acromion; a little while after, he felt a swelling at the middle of the clavicle on that side, attended with considerable pain. A surgeon pronounced it an undetected fracture, united with deformity; but J. L. Petit recognised in it a venereal exostosis, and treated it successfully with mercurial frictions. My own opinion is that J. L. Petit's diagnosis was based upon unsound reasoning, and the success of the treatment does not appear to me to be a positive demonstration of its correctness. Duverney relates the case of a child of ten or twelve, who had a fracture of the clavicle undetected for nearly fifteen days, and in whom there was commenced a very large and deformed callus. Cataplasms, mercurial frictions, and a plaster containing mercury, were used; in fifteen days extension and counter-extension were made without pain, and the child recovered very well. The use of the frictions proves nothing in this case; it does not prove much more in the other. I dwell upon these facts in order that practitioners, when in similar difficulties, may maintain a prudent reserve; I shall relate elsewhere, in connection with fractures at the sternal end of the bone, the history of another obscure case, the nature of which was only detected after some days.

The prognosis, considering the trifling severity of this fracture, is quite unfavorable. Slight as the displacement may be, the surgeon cannot promise union without deformity; the announcement from time to time of complete successes is due generally to the credulous exaggeration of the relators. The deformity diminishes in time, as

the osseous prominences are absorbed; *Fig.* 18 shows what may be hoped for in this way. When the overlapping is slight, the bone retains all its functions; indeed, it is generally stated that even extensive overlapping does not interfere with the motions of the arm. Although this opinion dates back as far as Hippocrates, it is none the less an error. I have already said that shortening of the clavicle notably impedes the backward movement of the arm, and so much the more, the more the shoulder is carried forward.

The treatment has greatly varied, not only as to the means of retention, but also as to the mode of reduction.

Hippocrates performed reduction in two ways; either, carrying the hand of the injured side over to the sound shoulder, and thus bringing the elbow forward, he pushed the latter forcibly so as to make the shoulder as pointed as possible, or he made the patient lie down on his back, with something thick between the scapulæ; now, an assistant raising the extended arm up over the ribs, the surgeon grasped the head of the humerus and pushed it outward with one hand, while with the other he made coaptation of the fragments.

Paulus Ægineta modified this last plan; the patient lying on his back, with a cushion between his shoulders, an assistant was directed to push the shoulders backward while the surgeon made the coaptation. He gives likewise two other methods: in the first, one assistant grasped with his hands the arm of the injured side, drawing it upward and outward, while another made counter-extension upon the sound arm, or still better, upon the neck of the patient. If the extension thus made was not powerful enough, a pad of linen or of cloth, of sufficient thickness, was placed in the axilla, and the elbow brought toward the body.

Another method which has been much in vogue in modern times, is described by Guy de Chauliac as devised by his teacher at Bologna. It consists in applying the knee between the shoulders to push the trunk forward, while with the hands the shoulders are pulled backward.

A. Paré, while using these plans of the ancients, added to them a peculiar precaution: he had the elbow carried backward, the hand of the injured side being placed upon the hip.

M. Grout has advised a still stranger posture, viz., to flex the forearm upon the arm to a right angle, and to bring it behind the trunk, in the lumbar region; approximating the elbow to the back, and raising it more or less, as may be necessary.

Lastly, I have sometimes tried pulling upon the arm carried out from the trunk, and even raised up at more than a right angle with it, when other modes of traction have failed.

Such a multiplicity of methods accords but badly with Boyer's statement that *there is no fracture easier of reduction.* The truth is, that in the majority of cases one easily succeeds in putting the

fragments in contact, whatever plan he may adopt; and that in other cases one plan may succeed where another fails, although I cannot at present offer any reason for this. Thus, in a child of ten years, who had at the same time a very severe wound of the head and a serrated fracture at the inner third of the clavicle, and who died on the same day, I found that the position necessary to obtain perfect coaptation was with the elbow carried upward and forward; while by carrying the elbow directly upward, and the shoulder outward by means of an axillary pad, the fragments were made to project forward.

Lastly, some cases are absolutely intractable by any method, and this not only when there are splinters, or various and extensive displacements, but where we have serrated fracture, apparently extremely simple, and with no displacement except upward or forward. In these latter cases, the only means by which I have succeeded in effacing this angle is strong direct pressure; but as soon as the pressure is removed, the angle appears as before.

On the whole, then, not being able to recommend any one as preferable to the rest, I would advise the surgeon, in difficult cases, to try all these plans for reduction one after the other; and we should be careful not to neglect, as is too generally done, direct attempts at coaptation.

Retention is still more difficult, and the apparatuses for it have been multiplied *ad nauseam*. Moreover, as there are only certain indications to be met, there are only certain means to meet them; and many of the apparatuses consist only of new combinations of means already known and employed, the special description of which would be unnecessary. It has seemed to me preferable to examine separately each indication, with the means of fulfilling it.

I establish here five leading indications. Three concern the outer fragment, which should be carried *upward, backward and outward;* the fourth concerns the inner fragment, which should be kept at the level of the other; and the last is to render both fragments immovable.

First Indication; to carry the outer Fragment upward.—The method which is at once the simplest and the most used, is to raise the arm by means of an ordinary sling, embracing the forearm and elbow, and suspended around the neck at the proper height; but as, in order to reduction, the position of the elbow sometimes has to be varied, so also must the position for its maintenance be varied; and the retaining apparatuses differ according as the elbow is to be kept applied at the side of the trunk, or forward, or backward, or outward.

To raise the elbow, keeping it close to the trunk, Hippocrates used the ordinary sling; or, if the patient would consent to stay in bed, he put a cushion under the elbow, to keep the shoulder raised as

much as possible by leaving it to its own weight. M. Flaubert has sometimes employed this latter method in the Hôtel-Dieu at Lyons.*

Some of the Greek surgeons substituted for the sling a bandage called a *fronde;* it was formed of a roller, which began above at the back of the shoulder, descended below the elbow, came up to the shoulder on the same side, and went over to the sound axilla, to be brought again to the arm on the injured side;† which is nothing more or less than Desault's third roller for fracture of the clavicle.

Lastly, Benjamin Bell gives the preference to a leather trough for the forearm and elbow, suspended by straps round the neck.

To raise the elbow when carried forward, it does not appear that Hippocrates used anything but the sling; and it was only toward the end of the last century that Flamant devised the first bandage specially designed to effect this. It was a small linen bag of triangular form, six or eight inches deep, and wide enough to embrace the elbow, the forearm being flexed. At the two angles of its opening, to wit, in front and behind, were fixed two bands with which to confine it. One of these bands was carried in front, and the other behind, to the sound shoulder, where they crossed one another; thence they descended to the outer part of the elbow, where they crossed one another again; and then they surrounded the trunk and arm by one or two circular turns.‡

Quite recently, M. Simonin has substituted for Flamant's sac a common cotton cap, deep enough to receive at once the elbow, the arm up to the axilla, and the forearm down to the wrist. Two broad ribands or pieces of bandage, about two feet long, are sewed, one at the posterior part of the opening of the sac, corresponding to the back of the axilla, and the other at the anterior part, nearly opposite the first; in such a way, however, that the cap being applied, this band comes behind the hand. This latter band goes up over the sound shoulder and down the back, to be knotted with the other one between the shoulder-blades, so as to keep the cap and the elbow suspended at the proper height. The elbow is then carried a little inward and forward, and fixed in this position by means of a third band; which, being firmly sewed to the inner edge of the cap about three fingers'-breadths from its top, passes in front of the chest, under the sound axilla, and round to the knot made by the other two bands, where it is itself fastened.§

M. Cruveilhier accomplished the same end with a strong cotton band thirty or forty inches long, and eight or nine fingers'-breadths wide, except at one end, where the width was reduced to five fingers'-breadths for the distance of about five or six inches. This band is

* Couronnè, *Thèse inaug.*, Paris, 1820, No. 226.
† Galen, *De fasciis.*
‡ *Journal Complémentaire*, tome xxxvi, p. 113.
§ *Bulletin de Thérapeutique*, tome xxiii, p. 34.

applied by its small extremity over the front of the chest, passing down and around the elbow; it passes up again between the elbow and chest to the axilla of the sound side, and thence to the nape of the neck, where it terminates by a semilunar notch surrounding the neck. From the two angles of this notch descend two cords, which are knotted to two similar ones from the angles of the other extremity. Lastly, to prevent the band from slipping where it goes over the elbow, it should be perforated over the olecranon, and if necessary further fixed by a few stitches.*

M. Velpeau uses two ordinary bandages, each about from eight to twelve yards long. The elbow being carried in front of the xiphoid cartilage, the hand laid upon the acromion of the sound side as if to grasp the shoulder, the end of the first bandage is applied at the sound axilla; thence it goes up back of the injured shoulder, descends along the front of the arm, and then goes outward below the elbow, to return to the sound axilla; this being done three or four times, we have so many diagonal spirals arranged obliquely to the fractured clavicle, to the axis of the chest, and to the middle of the arm. This done, the band is carried horizontally over the back, to be brought over the flexed arm and forearm, continuing these circular turns until the hand which rests on the sound shoulder, and the point of the one injured, are the only parts left exposed. The bandage is terminated by two or three more diagonal and one or two horizontal circular turns. The second bandage, well imbued with dextrine, is applied over the first in exactly the same way.

M. Mayor has recently spoken very highly of an apparatus constructed of a triangular piece of linen, long enough to amply surround the thorax. The elbow being carried forward and inward, the triangle is applied over it, its base upward and corresponding to the level of the lower third of the arm, its point hanging below and in front of the elbow. The two ends embrace the chest, and meet at the sound side, where they are fastened by pins or stitches. The arm and forearm being thus fixed to the side, the point of the triangle is brought up, passed between the forearm and the chest, and drawn strongly upward, with a direction at the same time toward the sound shoulder, so that it exactly surrounds the elbow, and holds it forward. After this there is sewed to the portion of the triangle which is behind the back the middle of another triangle, whose two ends pass up over the shoulders like suspenders; one of these ends goes over the sound shoulder, and is fastened to the end of the first triangle which was brought up as mentioned; the other, going over the fractured clavicle, descends perpendicularly upon the base of the first triangle, and is firmly fastened to it.

These two positions of the elbow, fixed at the side, or carried in

* Cruveilhier, *Médecine pratique éclairée par l'anatomie*, etc., 1821, p. 187.

front of the chest, are those which have principally obtained favor among surgeons. A. Paré, as was mentioned, preferred carrying it backward; and J. L. Petit says that he saw several cases thus treated; the forearm was not otherwise supported than by the ordinary sling. Dupuytren is the only one I know of, who has tried holding the elbow separated from the trunk; the patient was laid upon his back, with the upper extremity semiflexed and placed on a pillow.*

Second Indication; to carry the outer Fragment backward.— Although this indication has been recognised from the earliest times in reference to reduction, it was left for A. Paré to carry it out as a permanent thing, by an apparatus. This was nothing more or less than the bandage in the form of St. Andrew's cross, called subsequently the stelliform bandage, or the figure-of-8 of both shoulders. I shall not allude to the modifications of this proposed by J. L. Petit, Brasdor, and others, which are justly forgotten. The figure-of-8 made of straps and buckles, tried in 1790 by Brunninghausen, after having made some noise, was given up even by its author. Lastly, in modern times, MM. Récamier, Fabre, and Guillon have sought to revive it, making it of cloths folded cravatwise; in order to give it more efficiency, they all advise placing beneath the cross at the back a thick cushion stuffed with hair, or what is simpler, with bran or oat-straw.†

This dorsal cushion is not itself of so recent invention; De La Motte used it about the end of the seventeenth century. He laid his patient on his back, with a *small and very soft cushion* between his shoulders, directing him *to attend particularly to separating his shoulders as much as possible.*

After the figure-of-8 and the cushions, come a host of other much more complicated contrivances, which in the order of their dates may be arranged under three heads: *dorsal splints*, *corsets*, and *braces.*

The first attempt at a dorsal splint was the celebrated *croix de fer*, wrongly attributed to Heister, but in reality due to Roland Paul Arnaud, demonstrator to the schools of surgery [in Paris] during the first quarter of the eighteenth century. This was a piece of iron somewhat T-shaped, properly padded, the upright of which descended to the lower portion of the spine, where it was fixed by a strap buckled over the abdomen; the branches, three fingers'-breadths wide, came above the shoulders, and to their ends two shoulder-pieces, half leather and half iron, surrounding the shoulders and axillæ, were attached. If the shoulders were not thus sufficiently drawn back-

* *La Clinique*, May 3, 1827; and *Leçons Orales*, tome i, p. 110.

† Brunninghausen, *loc. cit.;* Récamier, *Bulletin de Thérapeutique*, tome xxii, p. 105; Fabre, *Journal des Conn. Médico-Chir.*, 1842, pp. 72 and 238; Guillon, *ibid.*, p. 196.

ward, a thick compress was placed between the scapulæ, raising up the cross and its branches, and thus attaining the desired end.*

This apparatus would seem to have been neither much employed nor much imitated. I find it stated by Sir A. Cooper that in 1814, at St. George's Hospital, in London, there was tried a simple splint placed transversely across the shoulders, which were attached to it by bandages, in order to overcome a luxation of the acromial end of the clavicle which resisted all other means. I mention this attempt because it embodies the same idea as the iron cross, and because the indication intended to be fulfilled by it was the same as in cases of fracture.

Something similar was recommended in 1835 for fracture of the clavicle, by Dr. Keckeley, of Charleston, U. S.† It consists of a splint twenty-seven inches long, three and a half wide, carefully padded in the middle, and placed across the back at the level of the shoulders. At each extremity of this is a mortise, through which runs a strap, also padded, and fastened by means of a buckle. The end corresponding to each side is fixed to the shoulder by the strap passing under the axilla, which is guarded by a small cushion with eyelets for the strap to go through.

The corsets have presented much greater variety. The first mention of them is found in Duverney, who does not name their inventor. "Others," says he, "use two shoulder-pieces of leather, joined by a strap passing between them, which is tightened as much as may be required to hold the two shoulders back; the space between the two shoulders being carefully padded with some soft napkins."‡

The first corset devised by Brasdor was very much modeled upon this. It was formed by two circular bands of leather to surround the shoulders; and at the edge of each band, behind, was sewed a piece of leather four fingers'-breadths wide by six in length, these two pieces being bored with eyelets along their parallel borders so that they could be laced together. But the stiffness of this apparatus causing excoriation, Brasdor modified it as follows:

In place of the two circular leather bands, there were shoulder-pieces made of double chamois-skin, well stuffed, sewed to the back-pieces above, and buckled to them below. The back-pieces were made of strong cloth lined with chamois-skin; they also were padded, and laced together in the middle. Thus constructed, the corset might generally answer; Brasdor however judged it useful to add leather sleeves, sewed to the shoulder-pieces, and lacing up loosely around the upper half of the arm. Lastly, this being found by experience to be liable to slip up on the neck, one or two straps were added, one end being

* Leclerc, *Chirurgie complète*, 1739, p. 328.

† *Amer. Journal of the Med. Sciences*, Nov., 1834.

‡ From a note by Deschamps, it would seem that Pipelet was the author of this first corset. See the *Journal Général de Médecine*, tome xxi, p. 283.

attached to the corset, and the other to the waistband of a pair of drawers, worn day and night.

Brasdor read his Memoir before the Academy in 1761; and at the same time or soon after, Legrand of Arles, Jauberthou and others proposed apparatuses of the same kind. That of Legrand consisted of two leather loops connected behind by iron buttons received into holes; Jauberthou used fustian for the shoulder-pieces, and connected them by a buckle.* Ravaton returned to the circular loops, but had them made of thin leather, and well padded; he brought them together behind by means of two buckles; but he added likewise two buckles in front, with the double object of keeping the loops at the angle of the shoulder, and preventing the apparatus from slipping up on the neck.

Evers, a German surgeon, gave in 1787 a description of a somewhat simpler contrivance, which very nearly approaches to the first corset of Brasdor. It was composed of two straps to surround the shoulders; these straps were sewed above, and buckled below to two oblong pieces of leather like those of Brasdor, except that instead of being laced together they were joined by three buckles. Subsequently, this corset having like all the rest the inconvenience of slipping upward, Hofer added a girdle fixed around the pelvis, to which the corset was fastened behind by two vertical straps.† Sir A. Cooper adopted this apparatus, all except the girdle, which he replaced by drawers like those of Brasdor.

I shall pass over a host of other corsets, more complicated, but no better calculated to fulfil the indications. Amesbury, on the ground that all the shoulder-pieces in use tended to depress the outer fragment, made his six inches wide, so as to embrace the summit of the shoulder and the upper part of the arm. This is the only peculiarity of his corset, which is otherwise quite complicated, and seems to be nothing more than an imitation of Brasdor's leather sleeves.

There remain to be described two contrivances with springs, the first of which, due to Brunninghausen, bears the name of the *elastic lever*, and is meant to act like the iron cross and the dorsal splints. It consists of a broad, thick, oval pad, arranged with springs so as to give it the required elasticity, and placed between the shoulders. From its sides pass off two iron branches, on a level with the shoulders, which are fastened to them by steel shoulder-pieces.

The other apparatus, devised by Hubenthal, presents at least a somewhat more original idea. From the back part of a girdle buckled around the chest, arise two springs curving upward and forward over the shoulders, drawing them backward by their mere elasticity.

* See Brasdor's Memoir, already quoted.

† See Richter's work and its Atlas.

They are fastened by bands to the girdle in front, so as to prevent their being disarranged.*

Third Indication; to carry the outer Fragment outward.—This indication really consists in overcoming the overlapping; and therefore in fact in making permanent extension.

Papini is the only one, if I mistake not, who has attempted to employ here the system of distension.† He made use of a splint arranged in front of and parallel to the clavicle, its inner end being fastened by means of a strap to a girdle buckled around the chest, as high as possible; its outer end abutted against a leather cap fitted to the injured shoulder; the rest of the apparatus it is not worth while to describe, but this idea merits notice.

Except in this attempt, the lever-plan has been exclusively employed; and always by means of a pad in the axilla, over which the humerus plays as over a fulcrum, the elbow being drawn in toward the side.

It has been seen that in order to make reduction, Paulus Ægineta put a linen or woollen pad in the axilla; but this pad is found long before his time in the dressing described by Galen under the name of *Spica of Glaucias*. In the seventeenth century, Fournier recommended a small cushion or pad, stuffed with linen, wool or hair; Duverney contented himself with a thick compress; Desault devised a cushion made with old linen, four or five inches wide, of the length of the humerus, but wedge-shaped, its base being about three inches thick, and fitting into the axilla. Boyer, finding the linen too hard, stuffed his pad with cotton. M. Al. Ricord has since contrived an air-cushion made of fine leather, cut and sewed so as to form a cone; within this is put a bladder, blown up from its urethral orifice, one part of the base being left open for this, and sewed up when the bladder is filled.‡ This was still of the same shape as Desault's pad; Flamant, in 1808, found the length of the wedge inconvenient, and shortened it to one-third or at most one-half that of the arm; he preferred the pad, which did not compress the muscles of the axilla.§ Lastly, Sir A. Cooper used oblong cushions, padded so softly as to fold around the anterior and posterior walls of the axilla.

The methods of keeping the cushion in place have likewise varied. In the Spica of Glaucias, as in Desault's apparatus, which is merely a modification of it, the pad or cushion was fixed by turns of a bandage. Boyer attached to the upper angles of his pad ribands, which passed up to be tied over the sound shoulder; Sir A. Cooper employed straps, passing backward and buckled to a corset like that of Evers.

* See for the first of these contrivances Richter's Atlas, and for the second that of Behrend.

† *Gazette Médicale*, 1835, p. 298. ‡ *Revue Médicale*, 1826, tome, i, p. 28.

§ *Op. cit., Journal Complémentaire*, tome xxxvi, p. 113.

It remains now to fix the elbow to the trunk. Glaucias and Desault do this by circular turns of a bandage, passing around the arm and the chest. Others have used a body-bandage instead of these; we have mentioned the method of Flamant and Cruveilhier for keeping the elbow forward. Boyer had a girdle made of cloth and quilted, five inches wide, fastened around the chest with three buckles, about on a level with the elbow. A cloth bracelet, also quilted, was laced around the lower half of the arm, and attached to the girdle by means of four straps and buckles, two in front and two behind, so that by tightening or loosening the lower pair, the elbow was carried more or less forward. This corset has served as a model for several others, such as those of Reynaud, Delpech, etc., which it is unnecessary to describe.

Fourth Indication; to depress the Sternal Fragment.—This indication was noted from the origin of our art, and has given rise to various plans. Some apply over the projection a number of compresses; others prefer a plate of lead; the whole maintained by turns of a bandage, generally the spica of the shoulder. This bandage being readily deranged, some would bind the trunk first in a girdle, and then attach to this girdle, before and behind, turns of a bandage pressing directly on the clavicle. Others, lastly, carry the bandage over the clavicle and under the perineum.

Hippocrates, who describes these plans, says that experience had shown him their inefficiency.

In the time of Celsus, however, this indication had been again taken up, and in the case of multiple fracture, a mould was applied over the fragments, lined with wax. Albucasis resorted to tow, pressed upon by a pad and splint along the clavicle; and we find these contrivances carefully preserved until the eighteenth century. It may be added that in our own time M. Mayor has again recommended cotton soaked in the white of egg, and a wire trough, not conceiving that he was merely following after the Greeks and Arabians.

Another attempt was made by Hubenthal, consisting in covering the fracture with a mould in plaster; and he says that he thus cured a fracture of the clavicle in a lady, without deformity.*

Lastly, recourse has been had to mechanical compression. Brasdor relates that he saw a young man in whom the prominence of the upper fragment was so great that Vacher, who was treating him, had had to use a pad almost like that of a truss; it was fixed upon a stem whose other end was fastened in the axilla of the sound side. Richter describes an apparatus of Zudnachowski's, in which the pad was arranged upon a spring, the other end of which was fixed in front of the axillary cushion. An analogous contrivance has been

* *Nouv. Journal de Médecine*, tome v, p. 212.

employed by M. Mélier, in which the spring was attached behind a very strong girdle, and came up over the shoulder of the injured side.

Fifth Indication; to keep both Fragments at rest.—There are, among the appliances which have been mentioned, some intended to maintain the fragments at rest, such as the mechanical compressors; but M. Guérin (of Vannes) first conceived of preventing any motion of the inner piece, by fixing the head and the sound arm. In order to this, he advised that the arm should be held firmly against the side, which was easily done by means of a body-bandage, and the face turned from the fracture, by a dextrine-bandage covering the head and the affected shoulder.

Such are the principal means devised to fulfil each indication; such the elements which, sometimes alone and sometimes combined, go to constitute all the apparatuses known. But it will not be without interest to study now these apparatuses in the order in which they have been brought forward, and to find out through what variations the practice of the profession has passed.

Hippocrates concerned himself with only two indications; to keep the shoulder elevated, and to act upon the fragments by means of compresses and bandages; he had however but little confidence in the latter. Glaucias and Paulus Ægineta attempted also to carry the shoulder outward by means of an axillary cushion; and these three were the only indications recognised and aimed at until the time of A. Paré.

A. Paré more particularly endeavored to carry the shoulder backward, founding in this respect a doctrine which prevailed for more than two centuries, and which even now has numerous partisans. Among his successors, some employed at once the pad, the sling, the figure-of-8, and the bandage above the fracture, thus trying to fulfil four indications; others limited themselves to the sling or to the figure-of-8, or used simple corsets.

Desault started another revolution, rejecting all the means in use for carrying the shoulder backward, although he had admitted that this indication was a constant one; but it is very evident that his dressing, copied from those of the ancients, could at most carry the shoulder upward and outward. These two were the main indications recognised by the school of Desault; thus Boyer, Flamant, and M. Cruveilhier carefully preserved the axillary pad; only the two latter thought that adducting the elbow in front of the chest would carry the shoulder backward; which it would do if the clavicle were sound, but not if it were broken.

While Desault returned to the views of the ancients, in opposition to the school of A. Paré, Sir A. Cooper returned to the views of this school in opposition to those of Desault; and he extolled the corset, combined with a sort of axillary pad. We have seen also, within a

few years, MM. Fabre and Guillon disputing as to the priority of an apparatus constructed as follows: (1) a cravat making a figure-of-8 around the shoulders, with a pad between the two scapulæ, to draw the shoulders back; (2) an axillary cushion and a circular cravat confining the elbow to the trunk, and carrying the shoulder outward; (3) a sling to carry it upward; thus fulfilling three indications. I have mentioned the means hitherto employed to depress the inner fragment and insure its contact with the other; and lastly the ideas of M. Guérin (of Vannes) as to preventing any mobility between the fragments. It should be added that M. Guérin recommends at the same time the use of Desault's dressing, starched or dextrinated, to satisfy the other indications.

But while for a century and a half we see the most celebrated surgeons striving to perfect, or perhaps more strictly to complicate, the contrivances for treating fractured clavicle, we may follow parallel to them another series of no less estimable surgeons, who disbelieving in these so-called improvements, return to the simplest means, as did Hippocrates before them. Thus De La Motte, Gasparetti, Bruns, Flajani, treated these fractures without any apparatus, only by the horizontal posture, placing at most a cushion under the back; and in our own day Dupuytren and M. Flaubert have followed their example.* Mr. Benjamin Bell merely suspended the arm in a leather splint; Sabatier, Chaussier, and Richerand have at last gone back to the simple sling;† and the apparatuses of MM. Mayor, Velpeau, and Simonin fulfil no other indication than that of raising the shoulder by carrying the elbow forward.

If now we seek to judge of all these contrivances by their results, we see that most of them are extolled as producing cures without deformity; but we see also that subsequent experience has always falsified these promises. It is not that regular consolidation is absolutely impossible: I have cited cases where there was no displacement, where union occurred even without any apparatus; and several surgeons have told me that they had cured without deformity fractures in which at first the fragments were displaced. I therefore regard the thing as not impossible, although for my own part I have never seen such an instance. But if it be so, why is it that such success is so rare and so exceptional? Several reasons may be given.

The first, pointed out by Hippocrates, is the intractability of our patients, and the impossibility of keeping them entirely at rest during the whole of the requisite time.

The second is the insufficiency of our appliances; and first it is worthy of remark that never yet has any surgeon thought of fulfilling

* Flajani, *Nuovo methodo di medicare alcune malattie*, etc., Rome, 1786.

† Ribes, *Mém. et obs. d'anatomie*, etc., tome ii, p. 72; Richerand, *Hist. des progrès récents de la chirurgie*, p. 132.

all the five indications we have mentioned. But this is not all; there are few of our means which do not in some way do harm; the shoulder-pieces of the figure-of-8 or of the corsets depress the outer fragment upon which they bear; the axillary cushion tends to slip forward in front of the chest, drawing forward the shoulder which it should push outward; it makes such painful pressure upon the skin, as to have sometimes caused excoriations, inflammation, and even sloughing. The pressure over the inner fragment tends to cause gangrene of the skin covering it; the bandages and splints applied over both fragments serve only to mask and not to prevent displacements; lastly, the sling itself, by elevating the shoulder, may cause such rotation of the outer fragment as to bring its superior face in front.

A third source of difficulty is in the different kinds of fractures, some being irreducible, and hence not to be maintained in exact position; while others are easy to adjust by coaptation with the fingers, but instantly become deranged when we attempt to replace the fingers by any apparatus. Ravaton relates an instance of oblique fracture in which he was obliged to perform reduction several times over, and advises that we should repeat it ten or twelve times or more within six weeks, seeing that in proportion as the callus becomes firm the displacement will be less and less likely to recur. I have treated a serrated fracture with displacement angularly upward, which disappeared under pressure with the thumb, only to reappear at once in spite of all the positions and appliances of which I could conceive; and it would be easy for me to multiply instances of recurrence quite as obstinate.

Lastly, we have also sometimes to blame the blind routine pursued by surgeons, who put confidence in one method, and seek to apply it invariably in all cases. It is clear however that as we must vary our means of obtaining reduction, we must also vary those for keeping it up. Hippocrates remarked that some fractures do best with the elbow placed at the side, while in others it must be carried forward; and Duverney also advises varying the bandage according to the fracture. Sometimes an attentive examination may even reveal new and special indications; thus M. Roche, in a difficult case, was struck with the tendency to projection of the lower angle of the scapula, as by a lever-movement; he prevented this projection by means of graduated compresses and bandages, and thus succeeded in keeping up exact reduction.* Such projection is generally the result of the shoulder inclining forward, and is remedied by simply drawing it back. Whence arise such differences; whence, for example, this superior advantage of one position over another? I have, for my part, many times had proof that it is so; but I cannot give any explanation that is at all plausible.

* *Archiv. de Médecine*, tome xix, p. 59.

On the whole, then, if the patient does not demand an exactly regular callus, and if the surgeon does not desire more than the usual success, he may boldly reject every form of complicated apparatus, bandages, cushions, corsets and splints, and merely keep the shoulder elevated or carried backward. One or two trials, made by the patient himself, will show sufficiently what is best, whether by means of an ordinary sling to keep the elbow to the side, or to carry it forward by means of M. Mayor's sling, or to draw the shoulders backward with a cravat arranged as a figure-of-8. The callus will be no more deformed, and the patient will have the double advantage of almost entire liberty of movement, and the least possible annoyance. It is merely necessary to guard the parts against excessive pressure; in order to this M. Velpeau puts a piece of linen, doubled, between the chest and the arm; M. Mayor applies his dressing over the shirt or waistcoat; in very thin persons the inner condyle and the point of the olecranon must be guarded with a little pad of cotton. With the same view, and also to prevent any loosening, I prefer to the sling an apparatus made with suspender-webbing and fastened by buckles; of this I shall give a more extended description in speaking of luxations of the clavicle.

If however great importance is attached to a perfect cure, the surest means, in my opinion, is to make the patient lie on his back for three weeks, his elbow fastened to his side or in front of his chest, his sound arm likewise kept at rest, his head immovably confined on the pillow, and lastly the fingers of an intelligent assistant applied permanently over both fragments; this was done by M. Mayor for a young lady in Berlin. I have thought of dispensing with this assistant by surrounding and confining the two fragments by two steel hooks, like the forceps of Museux; just as in the case of the serrated fracture with an angle upward, I thought of passing in at the summit of the angle a double hook, which by means of a strap and band could be drawn toward the elbow, thus exerting all the necessary pressure; and having this direct and powerful action, we might perhaps spare the patients the annoyance of remaining in bed. But these ideas need maturity; hitherto they have not been practically applied.

[In the United States, fracture of the clavicle at any point is treated mainly either by Velpeau's bandage, by a simple sling, or by Fox's apparatus. The latter consists of a collar, a pad and a sling; the collar is a stuffed ring to go over the sound shoulder; the pad is put in the axilla of the injured side, and fastened to the ring by tapes before and behind; the sling embraces the forearm and lower part of the arm, and is also fastened by tapes to the collar.

Dr. R. J. Levis of Philadelphia invented about two years ago a somewhat similar apparatus, consisting of a pad and sling, and bands fastened by buckles; it would probably in some cases be more

efficient than Fox's, but is somewhat more complicated, and requires greater accuracy in its construction. See the *Am. Journal of the Med. Sciences*, January, 1856, p. 100.]

§ II.—*Fractures of the Sternal Extremity.*

These fractures are very rare, and have hardly attracted the attention of observers. Lonsdale cites one case occurring from a direct blow in a child three years old, and presumes that it was a separation of the epiphysis. Quite recently the *Gazette des Hôpitaux*, giving an account of a patient in M. Blandin's wards, with a fracture situated *near the inner end of the clavicle, at the point where the first rib abuts against this bone, between the costo-clavicular and sterno-clavicular ligaments*, calls attention to the fact that in these cases there is no displacement, both fragments being kept immovable, the one by the first rib and the other by the sternum.*

This theory is incorrect; for the only two specimens in the Musée Dupuytren present a very considerable displacement, to which I shall presently refer again. When the fracture occurs without displacement, it is simply because of the interlocking of the fragments and the integrity of the periosteum.

These fractures without displacement may give rise to more than one error in diagnosis. I received into my wards in 1843 a man aged 28, who seven days before, having fallen into the moat at Vincennes, had felt a severe pain near the left sterno-clavicular articulation. I found there a hard tumor, formed apparently by the end of the clavicle being partially luxated forward; and such was my first impression of the case. However, as no manipulation diminished this prominence, I became doubtful, and called in some of my colleagues. M. Piédagnel thought it a tumor of ancient date and uncertain nature; M. Maisonneuve, a sanguineous infiltration; M. Bérard was inclined to the belief that it was a fracture in progress of consolidation; and this latter diagnosis was confirmed by the statement of M. Mayor, my interne, who had seen the patient before his admission, and had then detected crepitus.

When the external violence produces the displacement, what direction do the fragments take? In a specimen in the Musée Dupuytren, (No. 64,) the outer fragment makes a marked prominence downward and forward, and an analogous one may be seen in the bone represented in *Fig.* 20. Is this form of displacement constant? I propose this question without answering it, knowing of no other examples of this fracture than those which I have mentioned.

* *Gazette des Hôpitaux*, April 22, 1845.

§ III.—*Fractures of the Acromial Extremity.*

Less common than those of the body of the bone, but much more so than those of the sternal extremity, these fractures were not separately studied until the eighteenth century. Duverney first pointed them out as not being liable to displacement. Brasdor explained this fact by the equal tension of the deltoid and trapezius, inserted into the two fragments and keeping them balanced; unhappily for this theory, the only observation recorded in Brasdor's Memoir was that of a fracture of this kind in which *one fragment overrode the other*. But disregarding this fact, the absence of displacement has been still considered as constant; only that, with Bichat, it has been ascribed to the resistance of the coraco-clavicular ligament, which keeps together the sternal fragment, into which it is directly inserted, and the acromial portion, which is joined to the scapula, into which the ligament is likewise inserted. Without absolutely denying the action of this ligament, I think that the contact or derangement of the fragments depends mainly on the severity of the external violence and the integrity of the periosteum; in some of these fractures displacement may occur to as great an extent as in any others.

We say, then, first, that the seat of this fracture may vary from the acromial articulation to the inner border of the coraco-clavicular ligament, comprising an extent of about five centimètres. The cause is always either a direct blow, or a fall on the shoulder or on the extended arm. Generally the fracture passes from before backward, and divides the bone vertically; but it may be oblique, and hence give rise to different phenomena.

There is usually no appreciable displacement. There is little pain, hardly any impediment to motion, almost never any crepitus; so that often the only sign of the fracture is pain limited to the line of the division. There may, however, commonly be felt a notch, a very slight separation between the fragments, especially when the arm and shoulder are drawn downward. Sometimes the weight of the limb suffices to draw down somewhat the outer fragment; at other times, on the contrary, this fragment is a little elevated above the other. M. Guérétin observed, in a fracture situated at the level of the inner border of the coracoid process, the external fragment forming a projection upward of four millimètres.* Probably this was due to a certain obliquity of the fracture; in a specimen in the Musée Dupuytren, the fracture appears to have been oblique downward and outward, and the acromial fragment rides above the other. (See *Fig.* 20.)

In such circumstances, with little or no displacement, we can hardly see the use of the inventions of some authors for keeping the

* *Presse Médicale*, 1837, p. 43.

fragments in position. They keep in place sufficiently of themselves, and all that is necessary is to support the arm and shoulder with an ordinary sling.

But there are other cases, hitherto neglected, in which the displacement is very great; it is then always the inner fragment which overrides the outer. *Fig.* 21, and still more *Fig.* 19, give an idea of the nature and extent of these displacements; I have seen also in the living subject two remarkable instances of them.

A man aged 41 had sustained a fall, with his two arms forward. The right arm struck first, and the result was a fracture of the right clavicle, about one centimètre from the acromial end. He took no notice of it, and did not even have it seen by a surgeon. I examined it seven months and a half after the accident; the inner fragment was elevated nearly three centimètres above the other; the overlapping amounted to a centimètre; the shoulder was depressed, and carried forward and inward, so that a tape stretched from its point to the jugular fossa, showed three centimètres and a half less on the injured side than on the other; and to this inclination of the shoulder there corresponded posteriorly a notable prominence of the inferior angle and posterior edge of the scapula. Everything indicated, at the first glance, luxation upward of the acromial end of the clavicle; and I was only undeceived by making an exact measurement, and by the pointed prominence of the inner fragment. The man executed all the movements of the arm very well, except those in which it was carried backward; he had generally no pain, except about the humeral insertion of the deltoid, but changes of the weather caused pains at the seat of the fracture.

In the other case, almost exactly similar to this, the fracture had been caused by a fall backward on the pavement; it had been treated with an apparatus fixing the hand on the sound shoulder, and the prominence had been only slightly corrected.

Fractures of this kind call, therefore, for attention in respect both to diagnosis and to treatment. Their symptoms are so similar to those of upward luxation of the acromial end of the bone, that the comparative measurement of the two clavicles is sometimes the only means of avoiding error; and it would appear also that in some cases the projecting fragment requires direct and permanent pressure to replace it, just as does the clavicle in certain luxations. I say this only from analogy, having had no opportunity of seeing these fractures when recent.

§ IV.—*Fractures of both Clavicles.*

Fracture of both clavicles at once is extremely rare, having occurred but once among the 2358 cases at the Hôtel-Dieu; for my

own part, I have seen it but once, and have been able to collect but four other instances.

The first question is, How can such an accident occur? Now by a singular chance, the small number of cases known gives us instances of almost every imaginable cause. Thus there was in 1831, in M. Velpeau's wards at La Pitié, a man aged 35, who had old fractures of both clavicles, which, according to his account, were congenital. In an old soldier whose history is given by M. Gerdy, the two fractures resulted from blows with the butt-end of a musket,—a direct cause. M. Reynaud saw a man who had first the right clavicle broken by a falling piece of wood, and being knocked down by the blow, broke the other by counter-stroke; here was a combination of direct and indirect force. In the patient at the Hôtel-Dieu, the case was reversed; he fell first on the left shoulder, breaking that clavicle by counter-stroke, and then a carriage-wheel passed over him, and broke the bone on the right side. In another case, reported by M. Carrière, both fractures were indirect; the patient falling and finding himself wedged between two pieces of stone pressing the shoulders transversely.* My patient could give no account of the mode of occurrence of his accident; he had been thrown by a jealous husband from a window fifteen feet high, and did not remember any of the circumstances of his fall. It may be remarked that all the patients were men.

The symptoms do not differ from those of one clavicle alone; M. Carrière has noted that in his case the head was kept straight, without any inclination to either side.

But the chief difference lies in the consequences, and in the difficulty of treatment. Of the six cases mentioned above, non-union ensued in three. This result is less alarming when we recall that the two cases seen by M. Velpeau and M. Gerdy had not been submitted to any treatment; but mine, a young man of eighteen, had had applied a corset like that of Brasdor, and a pad in each axilla.

It is curious to examine the mode in which the functions of the arms were performed with this permanent fracture of both clavicles. The patient at La Pitié, with an overlapping of more than an inch on each side, and extreme mobility of the fragments, still enjoyed, it is said, all the movements of the arms. There is certainly some exaggeration here; and a close examination of my own patient did not give me anything like such a result.

I have stated how he fell, and how he was treated. Before his double fracture he had been a tinsmith; but he could not resume this occupation, and became a tailor. Three years afterwards, by a curi-

* See *Gazette des Hôpitaux*, Dec. 29, 1831; Gerdy, *Archives de Médecine*, 1834, tome iv, p. 362; Reynaud, *Bulletin de la Société d'Emulation*, 1811, tome viii, p. 323; *Gaz. des Hôpit.*, Oct. 13, 1831; Carrière, *Bulletin de Thérapeutique*, tome xxiii, p. 447.

ous fraud, he became a substitute in the 24th regiment of the line; but being unable to carry either knapsack or musket, he was on the point of being discharged when I examined him at Val-de-Grâce, in January, 1831.

Both clavicles had been broken at the middle; the two inner fragments were nearly horizontal, and very distinct beneath the skin; the outer fragments had also a nearly horizontal direction, but were buried behind and below the others, to which they seemed to have no adhesions of any kind. The overlapping was considerable.

When he stood up, the two shoulders seemed lower, as well as carried farther forward and inward than in a healthy person. The one on the right side was higher, and at the same time closer to the sternum than the other. Posteriorly, the scapulæ were separated from the spinal column by three or four inches, and inclined forward and outward; and on the whole the thorax seemed much contracted at its upper part.

He could draw the shoulders a little back, but not enough to overcome their apparent prominence anteriorly. On the other hand, he could draw them together forward so that they seemed like wings covering the chest, and leaving between them, in front of the sternum, only three inches' space. In this movement the scapulæ fitted to the sides of the trunk, and the back seemed rounded from one side to the other, almost like that of a skeleton deprived of the upper extremities. The shoulders could be raised also at will, but not to any extent, from want of muscular power.

He could raise both arms to a right angle with the trunk, but no higher; but in this movement the elbow had to be carried either forward or outward; to carry it backward was impossible. The mechanism of this elevation of the arms was very curious to observe. It was first the whole shoulder which was raised, and which at the same time was carried forward and inward; when this motion ceased, the deltoid acted and raised the arm; the scapula remained almost immovable, and its inferior angle did not advance two centimètres even at the highest elevation of the arm. For the rest, whether the arm was raised by voluntary effort or passively, the movement was arrested at either side by a painful sensation in the axilla; the patient said that he *felt a nerve stretched.* Moreover, neither the shoulder nor the arm of the left side could be brought up as high as those of the right. In all these movements of elevation the inner fragment of each clavicle was raised so as to make an angle of about forty-five degrees with the horizon; the outer one was raised also, but never as high as the other.

With such limited movements, it may be seen how the occupation of a tinsmith became very laborious to him; nevertheless, his forearms and hands being unimpaired in their action, he could easily do the work of a tailor. Still, when he worked a little more than

usual, he felt pain at the attachment of the pectoralis major to the inner fragment; and the same pain came on with any change in the weather. This part of the muscle was in fact more drawn upon than any other.

Thus then, as might have been foreseen, unconsolidated fracture of both clavicles is much more troublesome than that of one alone, and it is very important to ward off such a misfortune. Doubtless any intelligent surgeon would know how to modify the usual appliances to suit such cases; but it may be useful to state what has been done.

The simplest idea is to confine the patient to his bed. This was the plan adopted by Dupuytren, merely placing a pillow between each arm and the trunk. M. Reynaud likewise kept his patient in bed, but applied also such a host of corsets, braces, straps, cushions and slings, that I give up attempting their description. All this apparatus would seem moreover to have been of but very little use; and at most it would have been judicious to have added to the pillows used by Dupuytren a bandage, to confine the arms and elbows.

The case given by M. Carrière is more interesting, inasmuch as his patient was intractable, refusing to keep his bed even for a few days. The surgeon then tried a double apparatus, composed of two axillary pads, a large girth to act as a body-bandage, and lastly two slings to support the forearms and elbows. The patient could not endure this confinement of his hands, and sought every opportunity of disengaging them; then M. Carrière took another course; he dispensed with the pads and girth, and applied on the left side, where the displacement was most marked, the apparatus of M. Simonin; supporting the right arm merely by a sling forming a pouch for the elbow, so as to carry it upward and inward. Consolidation was complete by the twentieth day, and the man went to his work two days afterwards.

CHAPTER X.

FRACTURES OF THE SCAPULA.

Fractures of the scapula are so rare that Ravaton, after a practice of fifty years, declared that he had never seen any except those caused by gunshot on the field of battle. Among the 2358 cases at the Hôtel-Dieu there were only four. It may however be added that of 1901 fractures treated at the Middlesex Hospital, Lonsdale found eighteen of the scapula. Four principal varieties of them are recognised, according as they involve the body of the bone, the acromion, the coracoid apophysis, or the glenoid cavity; but as the latter are generally accompanied by displacements of the head of the humerus, their history may be better placed with that of those luxations.

[When resident in the Pennsylvania Hospital, I had in charge a little girl aged two and a half years, who had the neck of the scapula broken off, with mobility and crepitus; the head of the humerus was undisturbed. The injury was sustained by falling down three stairs. The elbow was supported, and the usefulness of the arm completely restored by the eleventh day.]

§ I.—*Fractures of the Body of the Scapula.*

Attempts have been made to distinguish numerous varieties of these fractures. In the first place J. L. Petit arranged them into transverse, oblique and longitudinal. Subsequently, Desault made a special variety of fractures of the lower angle; Bœttcher, of those of the posterior angle; A. L. Richter brought forward again, following Paulus Ægineta and A. Paré, fractures of the spine of the bone. I know of no instance of fracture limited to the spine or to the posterior angle, nor of any of vertical fracture; fracture of the lower angle does not call for special mention; and finally, the varieties which it is really important to recognise are incomplete, complete, whether transverse or oblique, and multiple or comminuted fractures.

They are generally the result of direct violence, such as a blow, the fall of a heavy body upon the scapula, or the falling backward of the

patient himself. Dr. Heylen has however recently published a case attributed to muscular action. A man aged 49, trying to climb into his cart, had caught hold of its edge with his left hand, and was thus suspended when his horse suddenly started off on a full trot. The man was thus dragged, hanging by his left hand, a distance of one hundred yards, until the horse stopped. He had severe pain in the left shoulder, increased by the least movement; the finger felt a depression at the middle of the spine of the scapula, and on pressing strongly upon the projecting portion, it gave way with crepitation. For the rest, there was no trace of ecchymosis externally, and the patient, who had not lost his presence of mind, affirmed that nothing had touched the shoulder.* Perhaps the cause here was the weight of the body, increased by the jerks from the jolting of the cart, and breaking the bone by a sort of traction; but however it may be explained, the case is still very remarkable.

I have seen but one case of incomplete fracture, and know of no other example. A laborer being at work in an excavation, with his back bent, a mass of building-stone weighing about twenty pounds fell from a height of four or five yards upon the left scapula. On examination I found a severe contusion at about the centre of the fossa infra-spinata; the finger, when pressed upon this, sunk into a very marked depression, limited within by a sharp bony prominence, and toward the outer edge gradually coming up to the level of the rest of the bone. The scapula moved *en masse*, and without crepitation. There was therefore a depressed fracture in the fossa infra-spinata. It may be plainly seen that in such a case art would have little to do; I merely fastened the arm to the side, so as to keep the scapula at rest until the pain subsided.

Complete fractures, whether transverse or oblique, are seated most frequently above the spine. They are sometimes unattended with displacement. M. Huguier told me he had treated a case of this kind, which he recognised by crepitation and slight mobility. Kirkbride has published the case of a man who was struck by a locomotive engine and thrown down, striking the rail; he had a transverse fracture about two inches below the spine; the fragments could be easily displaced, but resumed their normal relation when left to themselves. The patient dying on the fifty-fourth day, the fracture was found firmly united, and the callus extending across the bone.†

But most commonly there is more or less displacement, the result at once of the external violence and of muscular action. *Fig.* 24 represents the left scapula of a young epileptic, who long before his death had had this bone broken by a fall upon his back. There are two fractures, nearly transverse; in the first, situated below the

* See my *Journal de Chirurgie*, tome iii, p. 151.

† *American Journal of the Med. Sciences*, Aug., 1835, p. 307.

spine, the lower fragment presents a triple displacement, first forward, then by overlapping, and then outward. The second, situated near the inferior angle, offers nearly the same displacement, but a little more marked; and the overlapping in both together is such that the bone has lost fifteen millimètres [half an inch] in its length.

I have seen a somewhat different displacement in a man seventy-one years old, who was thrown down by a cabriolet. A fracture of the right scapula was detected, and treated by a simple body-bandage. By the thirty-fourth day, consolidation seemed to be complete; I examined carefully into the state of things; the fracture ran across the outer half of the fossa infra-spinata, and then passed up somewhat obliquely inward toward the edge of the spine. The lower fragment was very notably displaced outward; but so far from being driven forward, it made a projection backward; and the finger, passing downward along the edge of the scapula, was arrested by the very considerable prominence of this fragment, raising up the infra-spinatus muscle. Nevertheless, the two fragments were not completely separate from one another, for the measurement of the two scapulæ showed no sign of overlapping.

Lonsdale relates two cases of simple oblique fracture, but with very trifling displacements; the lower fragment being carried forward and outward, and the other riding over it. When the fragments are disjoined by greater external violence, the displacement assumes a new character which would not theoretically be looked for. *Figs.* 22 and 23 represent the two aspects of a scapula broken into numerous pieces; and one of these fractures divides the fossa infra-spinata from below upward and from within outward. Now in place of descending and overlapping the other, the upper fragment is drawn up backward, the lower drawn outward; so that, remaining in contact at the neck of the bone, they are separated posteriorly and below like the two legs of a pair of compasses. The patient had lived some time after the occurrence of the fracture; and consolidation had begun at several points, fixing the two principal fragments as is seen in the drawings. We may also see plainly that the lowest of the fragments, comprising the entire lower angle, is carried in front and outside of the middle fragment, over which it also rides, as in *Fig.* 24, already described. Probably there had occurred here very extensive ruptures of the muscular fibres; and perhaps such phenomena are only met with in cases of comminuted fracture.

The symptoms are generally as follows: local pain, augmented by pressure, by coughing or sneezing, or by the movements of the arm; passive motion being much less painful than voluntary. The latter was rendered almost impossible, in one of my patients, by the severity of the pain. Sometimes the head is averted, as in fractures of the clavicle. I noted in one case a considerable ecchymosis, but have not met with it in any other. J. L. Petit adds that emphysema is

almost always present; but no one else, so far as I know, has repeated this observation. So far we can but suspect the fracture; the really diagnostic signs are crepitation, mobility, and lastly, displacement.

It is difficult to produce crepitus by direct rubbing together of the fragments, because they afford so little grasp to the hand; we obtain it by putting the arm and shoulder through extended motions upward, downward, forward and backward, while we keep one hand laid flat over the scapula so as better to perceive it.

Mobility can hardly exist without displacement. In fractures of the lower angle, Desault carried the shoulder, and therefore the scapula backward, bearing with his fingers on the suspected portion. If the angle does not follow the movements of the rest of the bone, the fracture is incontestably proved; but even if it does, we cannot therefore with Bichat deny the existence of a fracture; the only consequence strictly derivable is, that there is no displacement.

The displacement is not always easily appreciable, especially in a fat or muscular patient, and where there is some little tumefaction. Any projections along the posterior edge may be well detected by making the patient cross his arms over his chest. Another method by which I have succeeded is as follows: the forearm is bent up behind the back, and the hand raised as high as possible; in this position the scapula is separated like a wing from the thorax, and its posterior edge, lower angle and external edge push up against the skin, and show in relief any abnormal prominences. It is thus also that we can best seize hold of the different parts of the bone, and try to make them play upon one another so as to cause crepitation. It is however well to be careful when we touch the fossa infra-spinata, not to be deceived by the edge of the bone outwardly, nor by that of the spine within and above, nor by that of the posterior edge near the lower angle, within and below. In case of doubt, we should examine both scapulæ in the same position, and carefully compare all their prominences.

With all these precautions, we may perhaps succeed in making out the presence of a fracture; but to say whether it is transverse or oblique, single or multiple, is again a difficult matter. Sometimes, when there is little or no displacement, crepitation will reveal a fracture, the seat of which cannot be determined by the touch; but a fracture without either displacement or crepitation will be almost inevitably unrecognised.

It is fortunate that then the mistake is of small importance; and the prognosis is no more serious even in cases with the most marked displacement. Mr. Benjamin Bell affirms that they very commonly give rise to permanent stiffening of the movements of the arm; but for myself I have never seen anything of the kind, and I have not

even seen any appreciable hindrance to motion in the cases I have observed.

Fractures without displacement require nothing but rest, and it is sufficient to keep the arm fastened to the trunk with a body-bandage and a sling.

When displacement exists, various modes of obtaining reduction have been tried. Pierre d'Argelata put a pad in the axilla, and drew in the elbow against the ribs. J. L. Petit advises raising the arm till the bend of the elbow is opposite the nose, and then that an assistant should hold it thus while the surgeon tries to adjust the fragments. Bell recommends raising the head and shoulders so as to relax the muscles of the back. Heister had the arm drawn forward; Desault, in fractures of the inferior angle, carried the arm in front of the chest and a little off from it, the hand of the injured side being laid upon the sound shoulder.

Surgeons have not been much more agreed as to the plan of treatment to be adopted. Paulus Ægineta treated these fractures like those of the clavicle, advising that the patient should be kept lying on the sound side. Albucasis applied a sort of pad over the bone, covered with compresses and with a wooden or leather splint. Desault employed a wedge-shaped cushion, the edge answering to the axilla and the base forming a fulcrum against the chest, for the arm; the whole was retained by a bandage seven or eight yards in length, the first few turns of which were intended to fasten the hand of the injured side upon the sound shoulder. Boyer, disregarding any displacement, attended only to keeping the bone motionless; and therefore, by means of suitable bandages, he fastened the arm to the side, carrying the elbow somewhat forward.

Among these different plans, how is the surgeon to make his choice? Are we to perform reduction, and have we any means of doing so?

The three indications to be fulfilled are, to carry the lower fragment backward and inward, and the upper forward and outward, and to correct any overlapping. The lower fragment seems drawn upon mainly by the teres major muscle; we must therefore, in order to relax this muscle, approximate the arm to the trunk, carrying it at the same time somewhat backward. The upper fragment appears to be acted on by the rhomboidei, which are relaxed when the shoulder is elevated and thrown back. As for overlapping, I know of no means of obviating it.

Mere position will doubtless be insufficient to correct the two former displacements; coaptation must be made with the hands, and then the permanent apparatus should comprise: (1) some means of keeping the shoulder upward and backward, and the elbow close to the chest, as in case of fracture of the clavicle; (2) some suitable substitute for pressure with the hands; a pad over the upper frag-

ment, pushing it forward against the other; graduated compresses internal to it, pushing it outward; and the same external to the lower one, pushing it inward.

This is at least what would seem to be indicated by the actual displacements and the most probable theory; but here, as in many other instances, nature laughs at our speculations; and for my own part, in the cases of this kind which I have treated, I have never been able to reduce the displacement by any of the means mentioned, and still less to keep the fragments in place. I should say, indeed, that positions apparently the most rational sometimes increased the derangement, which was lessened by others, varying in each case. If, therefore, the surgeon determines to accomplish reduction, the only advice which my experience authorises me to give is, to try all possible attitudes until he hits upon the best, and then to endeavor to maintain it during the whole time requisite for consolidation.

But in the majority of these fractures all this trouble is unnecessary; reduction, so often impossible to effect, is not of very great importance, and I merely keep the arm elevated by means of an ordinary sling, fastening it also to the trunk by means of a body-bandage.

§ II.—*Fractures of the Acromion.*

These fractures have seemed to me more rare than those of the body of the bone; but among the eighteen cases given in Lonsdale's table, we find eight of each. They were mentioned by Denys Fournier, in the seventeenth century; but Duverney was the first to report instances of them.*

They are sometimes produced by direct causes, such as the fall of some heavy body upon the top of the shoulder; Bichat has related one case,† and Avrard another.‡ But more commonly they result from falls on the shoulder, in which the acromion, striking the ground by its external border, breaks by counter-stroke at some point a little within this, and as by a force tending to bend it away from the arm. This mechanism is quite apparent in Duverney's two cases, and in another reported by Lonsdale. I have seen such a case also in a man aged 59, who, standing on the second round of a ladder, fell backward and struck his shoulder against an anvil.

The seat of this fracture varies. Sir A. Cooper cites a case in which it involved the articulation with the clavicle, and in which the clavicle was at the same time luxated; but it generally takes place back of this articulation, as may be seen in *Fig.* 25; an inch or less

* Chapter *De la fracture de la clavicule*, obs. 1 and 2.

† *Mém. sur la fract. de l'acromion; Oeuvres posthumes* of Desault, tome i, p 99.

‡ See my *Journal de Chirurgie*, 1845, p. 252.

from the point of the acromion, external to its posterior angle, near the point of attachment of the epiphysis. It follows a straight line, and generally divides the bone vertically; although M. Nélaton has seen a case in which it ran obliquely, the portion next the spine being bevelled at the expense of its superior surface.*

The symptoms also vary greatly. The shoulder displays commonly ecchymosis of greater or less extent, sometimes limited to the seat of the injury, sometimes spreading down toward the axilla, and even reaching the lower part of the arm. The swelling is due to the external violence.

The pain is sometimes very severe. In the instance which I observed, all movement was rendered impossible, so that the man could not even take off his coat. In Desault's patient the pain merely made motion of the arm difficult, and especially its elevation; it was increased by any such movements, and moreover, what is remarkable, by turning the head toward the sound side. Lonsdale observed in his case also the impossibility of raising the arm. But in one of M. Nélaton's cases, although the displacement was considerable, the patient, who was seventy-five years old, preserved all the movements of the arm, carried it forward, backward and outward, said that he felt no pain, and would wear no apparatus. I would say, however, that no express mention is made of elevation directly outward, which according to Lonsdale was the only impossible movement.

The diversity is as great in regard to the displacement. Sometimes the fragments remain in contact, nothing betraying the fracture externally; in a case of this kind, M. Nélaton discovered upon dissection that the periosteum had remained entire beneath, and that above it was but partially torn. With a more considerable rupture of this latter, the outer fragment would have slanted so as to make with the other an angle superiorly; as seems to have occurred in the specimen represented in *Fig.* 25. Had both sides suffered alike, the piece might have been more or less drawn down, without making any angle with the other; in the acromial fracture shown in *Figs.* 22 and 23, the descent amounted to a millimètre; but, what is quite curious, the fragment was carried also five or six millimètres backward. When lastly, the periosteum is ruptured completely both above and below, the outer fragment is entirely detached, and very much lowered. Thus in M. Nélaton's old man, just cited, in tracing the spine of the scapula an abnormal prominence was felt in front, and then a depression in which could be lodged the pulp of the finger. The acromion, depressed about half an inch, was entirely movable, and independent of the rest of the bone; when the patient carried the arm forward, the apophysis followed all the movements of the cla-

* *Sur les fract. de l'acromion*, in my *Journal de Chirurgie*, 1845, p. 178.

vicle, and at the same time the separation at the point of fracture increased so as to receive the ends of two fingers; this separation diminished, on the contrary, when the arm was carried outward and backward; in all these movements the acromion did not incline either way, but kept always its original direction. When the head was held straight, the shoulder seemed hardly altered to the sight, and the arm retained its normal position.

After this description from nature, it will be well to mention some points furnished by authors, which they have perhaps been enabled to observe, and which need verification. Bichat says that the head is turned from the injured side,—this is at least not constant. Sir A. Cooper says that the patient, immediately after the accident, feels great weight of the shoulder, and as if his arm was going to fall; he adds that the head of the humerus sinks into the axilla as much as the capsular ligament will allow, and lastly that the distance is lessened between the sternal end of the clavicle and the point of the shoulder. 'I do not know how to reconcile this shortening, which would imply a more or less notable overlapping, with the separation of the fragments mentioned by almost all observers.

Finally, there remains one phenomenon of no minor importance in the diagnosis; I allude to crepitation. Sir A. Cooper was the first to speak of it. If the surgeon raises the arm, lifting up the elbow, so as to give the shoulder its normal form, and then, placing one hand over the acromion, puts the arm through movements of rotation, he will according to Sir A. Cooper perceive a distinct crepitus. Lonsdale says he sometimes obtained it by alternately pushing up the head of the humerus against the acromion and lowering it, or by separating the elbow from the body; or again, when these plans failed, by bringing the arm outward and elevating it as high as possible.

It would seem that with all these ideas our diagnosis ought generally to be clear, and yet this fracture has been frequently misunderstood. Sometimes this is owing to the swelling, as in one of Duverney's observations, and in another of Lonsdale's; we should in that case wait till it subsides before pronouncing a positive opinion. It may be easily seen also that when the fragments are not separated the surgeon is very liable to err, and cannot arrive at anything but a probable diagnosis. But Sir A. Cooper relates a case in which the fracture and an accompanying luxation of the clavicle both went undetected; and I have given in my *Journal de Chirurgie* an account of a fracture of the acromion, supposed during life to be a luxation of the humerus, and discovered only at the autopsy. Such errors are deplorable, and prove at least great carelessness.

The nature of the cause, the ecchymosis, and the local pain, putting us on the track, we should explore with the finger the entire length of the spine of the scapula; if there is prominence and sepa-

ration, there is no room for doubt; if not, we should seek to move the outer fragment from one side to the other, or from above downward, or to obtain crepitation in any way whatever. The mere persistence of the pain induced Dugès, several months after a fall, to suspect a fracture of the acromion, without any crepitation or inequality; and the almost instant disappearance of the pain upon the application of a suitable apparatus, confirmed this bold diagnosis.* In fractures with notable displacement, I would advise also measuring from the acromion to the epicondyle, which is the real test of the depression; or measuring from the acromion to the sternum, if there is such a thing as overlapping, as Sir A. Cooper would lead us to suppose. The influence of the various motions of the arm upon the fracture needs also to be attentively studied.

The views of authors as to the prognosis are very contradictory. Heister and Boyer regard it as impossible to obtain exact union without any deformity; but while the former thinks that the movement of elevation of the arm remains always impeded, the latter says that a slight distortion would not at all compromise either the motion or the power of the limb. In Desault's patient, indeed, all the difficulty had vanished by the forty-eighth day; M. Janson even obtained a cure as complete in thirty days, in a much more difficult case; the acromion had been divided by a sabre-cut, and the skin had to be brought together with a twisted suture.†

Sir A. Cooper has pointed out another danger; osseous union, according to him, is rare in these fractures, and pseudarthrosis most commonly results. He relates a case of this kind; MM. Nélaton and Avrard have each seen one; osseous callus is wanting likewise in the specimens represented in *Figs.* 22, 23, and 25, and in another preparation in the Musée Dupuytren. Perhaps in these different cases we should generally be right in blaming either some bad complication, or the patient's intractability; in fact, in Bichat's case, consolidation was complete by the thirty-second day; one of M. Avrard's cases, although the bandage had been left off on the tenth day, had likewise subsequently firm union; I have myself seen a remarkable case, in which it was impossible to detect by the touch the seat of the fracture. I think a distinction should be established between fractures without displacement and almost without injury of the periosteum, and those which offer the contrary conditions; but even in the latter the treatment made use of, and the docility of the patient, would doubtless greatly influence the results.

When the callus does not ossify, Sir A. Cooper says that the fragments become connected by fibrous tissue. I have clearly made out this mode of union in the specimen represented in *Figs.* 22 and

* *Journal Univ. et Hebdomadaire*, 1831, tome iv, p. 201.
† *Compte-rendu de l'Hôtel-Dieu de Lyon*, from 1818 to 1820, p. 20.

23; but in that from which *Fig.* 24 was taken, the fractured surfaces seem eburnated, as if they had rubbed against one another, and I incline to the belief that a joint had been formed. However this may be, it may be well to note that in all the specimens I have seen, the upper edges of the fracture have been surmounted by little ridges of new-formed bone, of which the larger part belonged to the scapular fragment, (see particularly *Fig.* 25;) so that at first one would suppose that the process of ossification was more active here, and that the detached portion possessed less vitality. But another specimen in the Musée Dupuytren presents a strange phenomenon, obliging us to modify this conclusion. The outer fragment has a thickness nearly double that of the other; so that while its superior face is on the same level with the latter, the inferior one descends much below it; which has misled the editor of the Catalogue into calling it overlapping. It is on the contrary a hypertrophy of the detached portion, a phenomenon never yet, to my knowledge, pointed out, and which we shall have again to remark in other fractures.

Fracture of the acromion is reduced, when the outer fragment is inclined or depressed below the other, by seizing the arm near the elbow, and raising it directly upward; the head of the humerus thus pushes the detached part into place, and to maintain it so we have only to fix the arm in this position.

J. L. Petit's entire apparatus consisted of a sling. Heister added to this an axillary pad, and a spica around the shoulder. Desault applied an axillary pad of equal thickness throughout, and a bandage like that for fracture of the clavicle. Delpech advised having the pad which was placed between the arm and the side thicker below, so as to carry the elbow outward and relax the deltoid; but he preferred keeping the patient in bed, with his arm elevated nearly to a right angle. Sir A. Cooper, following the steps of Delpech, would have the axilla left free, and a cushion put merely between the side and the elbow, so as to keep the latter outward and a little backward. M. Nélaton tried in one case Mayor's apparatus for the clavicle, which draws the elbow forward.

I think myself that in most cases an ordinary sling is sufficient, aided if necessary by a body-bandage to fasten the arm against the chest. This was the treatment followed in the only case I have observed, and I have stated what the result was. If however in some exceptional cases reduction is found to be more complete when the elbow is carried outward, or backward, or in any other direction, we should of course prefer whatever apparatus will best keep up that position. I would merely remark that the shoulder should not be too much raised, for fear of giving the scapula that well-known position in which the external angle being pushed upward, the posterior looks downward and the inferior forward; which would have the effect of separating the two fragments, and making them form an angle up-

ward. Perhaps also we might, while pushing up the outer fragment, bear the inner one down to meet it. Desault's bandage, passing up from the elbow over the injured shoulder, fulfils this indication very well, but is too liable to become relaxed. The little apparatus with buckles, spoken of in connection with fractures of the clavicle, would be exactly the thing here.

Sir A. Cooper left the apparatus in place only three weeks; Boyer kept it on forty or fifty days. There is probably some exaggeration on both sides, and the space of thirty days would seem to satisfy all the indications.

§ III.—*Fractures of the Coracoid Process.*

This fracture is extremely rare, and hardly occurs except along with other fractures, and with immense contusion of the soft parts; so that the cases of it are generally very grave. Duverney relates the case of a girl aged 20, who fell into a quarry, and was found dead; the autopsy showed a fracture of the coracoid process, and one of the neck of the scapula, besides fractures of several of the ribs. *Fig.* 23 represents a fracture of the coracoid process, joined with numerous fractures of the scapula and humerus; the patient died before the callus had become solid. I have seen another instance, in which death was hastened by the occurrence of an enormous axillary abscess. A patient of the same kind, whose case is published by South, died on the fifth day; another, treated by Arnott, lived until the tenth.* Lastly, Boyer saw a fracture of the coracoid process, caused by a blow from the tongue of a carriage, in a man who died from the contusion of the soft parts; in this case the fracture seemed to be the only one present.

Boyer teaches that the fragment detached is drawn downward and forward by the pectoralis minor and coraco-brachialis muscles, and by the short head of the biceps; and Sanson adds that if the contusion be but slight we may grasp the fragment, and thus detect at once mobility and crepitation. As to this, we may remark that the coraco-clavicular ligament, which is inserted into nearly the whole of this process, holds the fragments quite close to one another, unless it is itself ruptured; and that pressure alone suffices to detect mobility, without trying to grasp the fragment, which would be exceedingly difficult. Monteggia treated a fracture of this process, which was recognised by the mobility and crepitation, although the fragments remained in contact; no apparatus was applied; he merely employed cataplasms, and the customary fomentations for contusion; and recovery ensued in a short space of time.

* *Archiv. Gén. de Médecine,* 1840, tome vii, p. 364.

Our art possesses hardly any other resources; only it may be useful to put the arm into a sling, the elbow being drawn forward and inward, with the double view of lessening the tension of the muscles inserted into the coracoid process, and keeping all the neighboring parts at rest.

Morelot says that he employed successfully, in one case, Desault's bandage for fractured clavicle, taking care to apply graduated compresses over the broken process. It would be difficult to imagine anything more irrational; and these compresses would only drive in the fragment, instead of keeping it in place. Moreover, the diagnosis was very doubtful, and the real condition of the process was not ascertained either before or after the treatment.*

[During my eighteen months' residence in the Pennsylvania Hospital, I saw six well-marked cases of fractured scapula. One was in a child two and a half years old, was caused by falling down three stairs, involved the neck of the bone, and united perfectly in two weeks. Another was in a man of about thirty, who had been struck by some falling boards; it was near the neck of the bone, and the contusion was very severe; he went out in twenty-seven days, before his cure was completed. Another was in a man of twenty-six, who had been struck by the crank of a hand-car on a railroad; there was much contusion, and the fracture was a comminuted one of the body of the bone; it was entirely cured in thirty-two days. Another was combined with a fracture of the clavicle, in a man of about fifty-five; it was seated in the body of the bone, and was caused by a fall down a cellar-way; he recovered the use of the arm in about six weeks. Another was in a woman aged 28, who fell down a flight of ten stairs, and broke off the lower angle of the right scapula; she was completely well in seventeen days. The sixth and last was only discovered after death, in a negro man who was injured by the fall of a derrick, which had broken also his thigh, and the spinous processes of three vertebræ. It was comminuted, and partly fissured. In the second, fourth, and fifth of these cases, the fracture was on the right side; and in the first, third, and last, it was on the left. The apparatus used in each case was merely such as would keep the arm still.]

* *Journal Général de Médecine*, tome xix, p. 287.

CHAPTER XI.

FRACTURES OF THE HUMERUS.

THESE fractures are very common, ranking in this respect with those of the clavicle; but the proportion of the two varies in different years. Of our total of 2358 fractures, 317 were of the humerus,—more by nearly one-third than those of the clavicle; but even at the Hôtel-Dieu, in one of our three series of years, these latter fractures were in excess; and at the Middlesex Hospital, Lonsdale counted 273 fractures of the clavicle to only 118 of the humerus. The influence of sex and age had much to do with these differences.

Of 310 simple fractures of the humerus, 206, or two-thirds, were in males; one-third only affected the other sex.

Classing them according to age, we find:

From	2 to 20 years	- - - - - -	45
"	20 " 40 "	- - - - - -	80
"	40 " 60 "	- - - - - -	105
"	60 " 80 "	and above - - - -	80

Whence it may be seen that without being rare in infancy and adult age, they are notably more frequent in more advanced life; but women especially seem much more exposed to them in old age. Thus I have found:

From	2 to 20 years,	of	45	fractures,	9	women,	= $\frac{1}{5}$.
"	20 " 45	"	105	"	28	"	= $\frac{1}{4}$.
"	45 " 60	"	80	"	29	"	= more than $\frac{1}{3}$.
"	60 " 80	"	80	"	38	"	= nearly $\frac{1}{2}$.

The influence of the seasons is very nearly the same as that of age; for instance, eighty-nine fractures occurred in the three winter months, sixty-six in the three summer months; spring and autumn affording a mean between these two extremes.

Fractures of the humerus present many varieties. Those of the great tuberosity come under the head of luxations, along with which they generally occur; at the other extremity, those which enter the joint belong rather to the chapter on fractures of the elbow. It remains, therefore, for us to examine here: (1) extra-capsular fractures of the upper extremity, or of the cervix humeri; (2) intra-capsular fractures, or those of the head of the humerus; (3) fractures of the

shaft; (4) fractures of the lower extremity, or just above the condyles; (5) fractures of the epicondyle.

§ I.—*Extra-Capsular Fractures, or those of the Cervix Humeri.**

We call that part of the humerus the neck, which is comprised between the head and tuberosities on the one hand, and the insertion of the latissimus dorsi, teres major and pectoralis major, on the other. Some surgeons, and recently also Sir A. Cooper,† extend the term as far as the insertion of the deltoid, but without any reason or use.

[In America, as in England, the humerus is said to have an anatomical and a surgical neck; the former the slightly constricted portion of the bone just above the tuberosities, and the latter comprising all below this as far as the insertion of the deltoid. This muscle exerts so marked an influence upon the deformity in any case of fracture above its lower attachment, that such an extension of the term surgical neck would seem to be entirely warranted.]

Fractures of the neck may occur at different points; one may be seen in *Figs.* 22 and 23, which is quite distant from the joint, and actually affects the shaft; Sir A. Cooper has represented one of the same kind; but these cases are rather rare, the fracture generally dividing the bone just where the junction of the diaphysis with the spongy portion is clearly defined, and where for this very reason less resistance is offered to any external violence.

These fractures are among the most common of all; for my own part, I have seen them nearly as often as those of the cervix femoris. They particularly affect old persons; the youngest patient I have treated with one was fifty-three years old, although they may occur at all ages. Sir A. Cooper even goes so far as to say that they are more frequent in infancy than in old age; but this seems to me to be a great mistake.

They are usually the result of direct violence, such as a fall, or a violent blow on the point of the shoulder. Two cases are, however, reported in Desault's journal, caused by falls on the elbow, and another by a fall on the hand; and analogous cases have been cited by other observers. Moreover, M. Goyrand seems to have seen a fracture of the surgical neck from mere muscular contraction in throwing a ball; though, to be sure, severe and deep-seated pains had been felt in the arm for six months previously.‡

* Malgaigne, *Mém. sur les fract. de l'extrémité sup. de l'humérus; Journal de Chirurgie*, Sept., Oct., and Nov., 1845.

† *On fractures of the head and neck of the os humeri; Guy's Hospital Reports*, Oct., 1839.

‡ Vidal, *Pathologie externe*, tome ii, p. 114.

The direction of the fracture is generally transverse, with numerous serrations at its circumference; more rarely it is oblique, and then its direction is mostly from above downward, and from without inward, parallel to that of the anatomical neck; at other times again it is complicated with small splinters, or with fractures in other directions, as, for instance, extending to the tuberosities. Lastly, sometimes it is combined with fracture of the head of the bone; to this I shall recur in speaking of the latter.

But a principal fact, and one which I think I have placed beyond doubt, is that whatever may be the anatomical form of the fracture, in the great majority of cases there is no appreciable displacement. The fragments are kept in position by the resistance of the periosteum and of the long head of the biceps; and among more than twenty fractures of this kind, I have seen but two in which the displacement was perceptible.*

The nature of the displacements is quite variable. Most frequently the fragments do not more than half leave one another; one end slides on the other by one-third or one-half of its thickness, and generally the lower fragment is carried inward or toward the axilla. (See *Figs* 22 and 23.) But it may also take the opposite direction; Desault saw it thrown backward; Dupuytren, Palletta, Duret, and others have seen it push up or even perforate the deltoid; lastly, still more commonly, it projects forward, toward the coracoid process; of this M. Debrou has seen three cases in one year at the Hôtel-Dieu in Orleans,† and Sir A. Cooper even makes it in children one of the constant phenomena of this fracture; an assertion too contrary to known facts to need formal refutation.

It is evident that such various displacements cannot all be attributed to muscular action. When the fracture is transverse, the only real cause of displacement is the impulsion given by the external force; when it is oblique, the displacement is generally influenced altogether by the direction of the obliquity, and there is added besides a more or less marked overlapping. But we must bear in mind that here the mobility of the head of the humerus upon the glenoid cavity may cause a change in the displacement, as well as in the direction of the fracture. In a very remarkable case observed by M. Gély, the lower fragment, which came to a sharp point, had perforated the deltoid anteriorly, close to the interstice between it and the pectoralis major, and there had consequently been diagnosed a fracture obliquely downward and backward. This was an error, as

* [It may seem as though this paragraph were at variance with what follows; but even if the cases in which there are displacements constitute a very small minority of the whole number, they may be sufficiently numerous to allow of great varieties among themselves.]

† Debrou, *Lettre sur une variété de déplacement du fragment inférieur*, etc.; in my *Journal de Chirurgie*, December, 1845.

it was in reality downward and inward, parallel to the plane of the anatomical neck. We should suppose then that the lower fragment would have projected outward, so much the more since it had penetrated the spongy tissue of the other fragment. But the head of the humerus having undergone a rotary movement from before backward, by reason of the external violence, the lower fragment, attached to it externally, was drawn forward by its rotation backward; it remained entangled in the tissues, and was thus found at the autopsy, which was made nearly eighteen months after the accident.*

Thus it is then that, with a fracture obliquely downward and inward, the lower fragment may project sometimes outward, sometimes forward, sometimes even backward, from the external violence, and by rotation of the upper fragment, without the two ceasing to be in contact. Occasionally the lower fragment passes through the muscles and partially through the integuments, so that it is felt nearly bare beneath the finger; M. Gély has noted this circumstance, and similar cases have been seen by Palletta and M. Debrou.

Lastly, the fragments may entirely abandon one another. Bichat says that he has seen the lower fragment carried upward with so much violence as to pierce the integuments and pass up much above the level of the head of the bone; and M. Guérétin has published another case of this kind, to which I shall again refer directly. In general, the lower fragment is merely thrown into the axilla, pushing forward the pectoralis major; but there is one peculiar form of its displacement, which is perfectly represented in *Fig.* 33.

This specimen was taken from an old man of seventy-seven, who died in my wards on the twenty-sixth day after the fracture, which it had been impossible to reduce. The lower fragment is in the first place seen to be thrown inward and forward, and in fact during life it pushed against the tissues close to the line between the deltoid and the pectoralis major, farther inward than the coracoid process; the overlapping was betrayed during life by shortening of the arm to the extent of nearly an inch. The fracture was seated below the tuberosities and the capsular ligament, which latter was nowhere opened, and about an inch above the insertion of the pectoralis major; it was transverse, with numerous serrations around its edges; and *Fig.* 34 shows a splinter which had been detached from the lower fragment and buried within the upper, as seen in *Fig.* 33. This upper fragment, free from any adhesion, had been drawn up by the supra-spinatus and probably by the other scapular muscles into such a rotation upward and outward that the great tuberosity is buried under the acromion; the fractured surface looks outward and

* Gély, *Fract. du col anat. de l'humérus; Journal de Chir.*, 1844, p. 315. This title is inaccurate, as the author himself remarks in the course of the article.

even a little upward, and the articulating head is turned inward and downward. I have detached the capsular ligament on this side so as to make this arrangement more distinct. In a word, the upper fragment is in a position answering to the greatest elevation of the arm in the normal state; the lower, on the contrary, in a position answering nearly to its greatest depression; it may be seen that this latter is in contact with the capsular ligament, and that by drawing it downward nothing would be gained but to get it below the capsule. The dotted lines running upward and outward show the exact position into which the lower fragment would have to be brought, in order to exert rational traction, and bring the fractured surfaces into perfect contact. I must not omit to say that the long head of the biceps would not allow such a displacement to occur, unless it had been turned out of its sheath; and on the lower fragment may be seen the transverse depression hollowed out by it in the swollen periosteum, as it thus goes round to reach its place of entry into the capsule.

When the fracture exists without perceptible displacement, the symptoms are: quite severe pain in the shoulder, increased by pressure or by the slightest movement; incapability of voluntary motion; swelling of the shoulder; ecchymosis; and lastly crepitation.

The impossibility of movement is not always absolute, and some patients can still carry the arm in different directions to a slight extent. The swelling is sometimes considerable enough to mask the displacement, and even to prevent our hearing crepitation; of this I have recently seen an instance. It appears to result mainly from effusion of blood beneath the deltoid, making the muscle bulge outward, and singularly increasing the concavity of the external surface of the arm below. The ecchymosis demands special attention. Sometimes it is present on the first day; frequently only after several days. It may show itself on the inside, in front, behind, or on the outside of the arm, and commonly it occupies several of these positions at once; sometimes it is limited to the point of the shoulder, and again it may invade the whole arm, or even extend to the walls of the chest. It is very rarely entirely wanting; and I have seen but one case in which the fracture was attended with only a very slight ecchymosis below the clavicle. A fact of importance as to the prognosis is, that except in the few cases in which the ecchymosis was hardly perceptible, I have generally seen it persist beyond the time required for consolidation; so that the patients recovered from the fracture before they did from the ecchymosis.

All these symptoms cannot however warrant more than a probable diagnosis; crepitation alone can make it positive. This is best elicited by grasping the elbow and rotating the arm in different directions successively. It is but rarely that it cannot be thus communicated to the other hand grasping the point of the shoulder; and

sometimes it is extremely well marked, probably when the fracture is attended with splintering.

When there is transverse displacement merely, the symptoms remain the same, except the projection of the fragments, and the inclination of the elbow in the opposite direction to that of the other end of the lower fragment. When there is overlapping added to this, we ascertain it by measuring the anterior wall of the axilla, from the clavicle to the edge of the fold, or by measuring the arm from the posterior angle of the acromion to the point of the epicondyle; observing the precautions necessary in the diagnosis of fractures generally. The diagnosis is still more clear when the fragments are entirely separated; the presence of the head of the bone under the acromion; a depression below the head, the shortening of the arm, and the mobility in all directions of the lower fragment, preclude all idea of a luxation; and in the case represented in *Fig.* 33, there was not even any prominence in the armpit.

These fractures, when there is little or no displacement, consolidate rapidly, not requiring for this more than thirty days. But there remains long afterwards a stiffness, and a difficulty in moving the shoulder; and however great care may be taken, the motion of elevation of the arm will always remain limited; at least I have in no case seen it perfectly restored, even after the lapse of from eleven to fifteen months. Besides the share taken by the joint in the irritation excited by the fracture, pathological anatomy has shown me another cause of this loss of motion; it is a particular form of displacement, so slight that it is not revealed by any symptom during life, but very apparent when the bone is quite stripped of the soft parts. *Fig.* 30 represents it perfectly.

In this humerus, sawed vertically through the middle, the fracture, which is of very ancient date, seems to have divided the bone just at the junction of the compact with the spongy portion. Thus the head and the tuberosities have undergone no change of shape; only by comparing them with their normal direction, (indicated by the dotted line,) we see that they have been displaced inward by nearly a centimètre, and that at the same time the greater tuberosity has been carried upward, and the head inclined downward on the inner side of the shaft. The upper fragment has therefore gone through a rotation like that shown in *Fig.* 33, just described, but arrested when at a very slight degree by the resistance of the lower fragment, the inner portion of which seems buried in the spongy tissue of the head of the bone. This is an actual penetration, appearing here much more considerable than it really is, owing to the neck being carried along the inner face of the shaft. The neck has left on the outside some irregularities which do not appear in the figure, and has even at one point completely filled up the bicipital groove. But the essential and ineffaceable result of the displacement has been to

limit, by nearly a centimètre, that motion of the head of the humerus on the glenoid cavity which constitutes elevation of the arm, and thus to restrain the extent of this elevation. I have seen several other analogous specimens, and shall recur to them in the next article.*

When there is overlapping and projection of the lower fragment, the formation of callus still occurs between the portions which remain in contact, but it is less solid, as would be supposed; M. Letenneur exhibited to the *Société Anatomique* a callus of this kind, dating back five years, which had been gradually destroyed by absorption, and was at last broken toward the close of life; the patient was however affected with cancer.† As to the point projecting beneath the integuments, it is quite promptly reduced and removed by absorption.

When, finally, the fragments are entirely separated, it may occur that from the attempts at reduction very grave suppurative inflammation is set up in the cellular tissue of the axilla; it was such an accident which carried off my patient. When all danger of this kind has gone by, but the broken ends remain displaced, a case observed by M. Danyau may teach us what to expect. The arm was shortened by an inch, its movements rendered difficult, and that of rotation impossible; the hand could not be carried to the top of the head, nor the elbow brought in to the side.

From all that precedes, it is evident that in the majority of cases there is no reduction to be made, since no displacement can be detected. When the fragments are somewhat deranged, but still remain interlocked, it is necessary to make sufficient extension to enable us to bring them back into their proper relation; and perhaps the traction could be made to better advantage with the arm raised nearly at a right angle, and the forearm semiflexed, the muscles being thus relaxed. In one case in which the lower fragment was caught in the skin, all efforts to disengage it having failed, the surgeon, M. Vallet, of Orleans, made a small puncture at some little distance off, carried a narrow probe-pointed bistoury between the bony point and the skin, and divided the bridles of tissue retaining the point without otherwise injuring the skin; the little wound was covered with lead-plaster, and healed without any suppuration taking place. This result deserves to be compared with the failure of an analogous plan before mentioned, (see page 162.)

But if we have to deal with fragments completely separated, we must resort to manœuvres more precise than those laid down in the books, and, moreover, attempted in a different way. According to the attentive examinations I have made of the distorted position of

* Sir A. Cooper has had represented a specimen of the same kind; (*loc. cit.*, pl. vi;) but without comprehending its significance.

† *Bull. de la Société Anatomique*, July, 1838.

the superior fragment, proper extension could not be made except by raising the arm outward to more than a right angle, so that the elbow should be above the extended axis of the clavicle. In this way alone can we hope to bring the fractured surfaces into contact; and probably if this contact were once obtained, the fragments might become so interlocked that the arm could be brought down close to the trunk, and into a less painful position. But I cannot too much insist on the fact that by drawing upon the arm while it hangs close to the trunk, nothing is gained except to bring the lower fragment against the capsular ligament.

In order to maintain the reduction, two things are to be attended to: the position of the limb, and the apparatus. Before the eighteenth century, there were three principal methods, viz., that of Duverney, who kept the patient lying on his back, with his arm supported at a right angle by cushions; that of Moscati, who likewise kept the patient in bed, with his arm supported upon cushions, but only slightly separated from the trunk; and that of Ledran, who fixed the arm parallel to the trunk, putting between them a sort of pad of linen, one finger's-breadth in thickness. Desault subsequently combined Moscati's method with that of Ledran, giving the pad the form of a wedge, whose base, three or four inches thick, being placed opposite the elbow, held the lower end of the arm farther from the side than the upper; Boyer, on the contrary, turned the base of the wedge upward, so as to bring the elbow toward the side and push the upper extremity outward. Dupuytren followed Desault with regard to the position of the limb; Richerand carried out Boyer's idea still further, by bringing the elbow inward and forward, the hand being laid on the sound shoulder.

Now, since we understand the relative position of the two fragments even in the simplest fractures, we may at once exclude Boyer's method, and much more that of Richerand, as utterly irrational. Since the fragments already tend to form an angle opening inward, the more we bring the elbow farther in than the top of the humerus, the more we increase this angle; Desault and Dupuytren therefore showed, I do not say better views, but better judgment, by keeping the elbow outward. And yet such slight abduction would not seem fitted to replace the lower fragment when more or less entangled with the other; and I would about as soon leave the arm close to the trunk.

As for the apparatus, the simpler it is the better. Rest in bed is by no means necessary; the spica, the pads, and the splints are entirely useless; it is sufficient merely to keep the forearm in a sling, not raising the elbow too much lest we increase the angle of the fragments; and a body-bandage may be added so as to insure more perfect immobility. I cannot understand the use of splints except when the lower fragment projects either anteriorly or posteriorly; then,

indeed, the splint applied over the prominence would tend to push it into place, while the other splint would do the same for the other fragment. They may easily be fastened around the arm below, and above over the shoulder, beyond which they ought to reach.

[A very excellent plan for the treatment of all fractures of the humerus near its upper extremity, is to use an inside angular splint, a wedge-shaped pad, the size of which should be regulated by the amount of deformity to be overcome, and a pasteboard cap for the shoulder. Reduction being made as carefully and completely as possible, the splint is fitted to the arm, the pad being so arranged at its upper end as to obviate the displacement; these being now bound to the arm by a roller, the cap, well padded, is laid over the shoulder, and by turns of a wide roller over the shoulder, upper part of the injured arm, and body, the dressing is completed. Should the lower fragment project forward or backward, the padding of the cap may be so disposed as to make pressure at any desired point. Very good results have been observed from the use of this method in the Pennsylvania Hospital and elsewhere.]

The overlapping in oblique fractures is more difficult to overcome, and our only means of doing this is by permanent extension. Two methods have been devised: *traction* and *leverage*. M. Coillot makes traction as follows:

His apparatus consists essentially of (1) a stick of wood of the thickness of a finger, placed vertically in front of the shoulder, above which it extends, and reaching down below the elbow, passing behind the semiflexed forearm; (2) of two tapes, two fingers'-breadths wide; (3) of cushions for the axilla and elbow. One of these cushions is put into the axilla, and so folded before and behind as to press as much as possible only in these two directions. In order better to secure this object, it is covered before and behind with two bits of pasteboard, and the whole bound together by the first of the two tapes, the two ends of which pass up to be fastened at the top of the stick; this makes the counter-extension. The bend of the elbow being well protected by the other cushion, the second tape is applied to it in the form of a figure-of-8, whose two ends are fastened at the lower end of the stick so as to make extension. It should be remarked that the tapes are fastened by means of a buckle above and below, so that the loops may be tightened or loosened at will. Lastly, in order better to avoid pressure beneath the axilla, M. Coillot passed through the loop of the upper band a small tape, called by him *lacs de rappel*, which, going down to be fastened to the stick, drew the loop away from the axilla, preventing it from pressing except upon the folds anteriorly and posteriorly.

In spite of these precautions, the patient suffered much from pressure, especially about the elbow; the fingers grew numb, and the whole extremity began to swell, till at last the symptoms became so severe that the apparatus had to be removed. The author adds,

however, that the reduction was permanent, and that the overlapping was so completely overcome that the arm even presented *a slight excess in length.*

M. Gély has tried the lever-method in the following manner: with three splints nailed together by their ends, he constructs a solid triangle whose apex presents an angle of somewhat more than 90°. The base of this triangle is placed along the side, which is duly protected; its lower angle reaches the crista ilii, its upper, well padded, the axilla; one of its shorter sides serves as an inside splint, and carries the arm away from the body; the apex of the triangle, directed outward, occupies the bend of the elbow, at a distance of twelve centimètres from the side, and lastly, the forearm fits along the third splint. In this apparatus, the axillary angle bears against the outer edge of the scapula, so as to make counter-extension; the forearm is the lever, which, working over the outer angle, draws outward the elbow and the lower fragment,—the length of the humeral splint being so calculated as to produce this effect in the most satisfactory manner.

This apparatus was applied in the case of a woman aged 29, who had an oblique fracture of the cervix humeri, the lower fragment projecting forward quite close to the skin. The patient was laid on a perfectly flat bed, and the elbow raised by means of a cushion, so as to carry the lower fragment backward. She showed great tractability, and the apparatus seemed to have the effect of preventing the upward projection of the fragment, which had threatened to pierce the skin; but on the whole, after it had been kept on for forty days the projection was apparently about the same.

This result is less brilliant than that in M. Coillot's case; perhaps it is nearer to the sober reality. We might doubtless resort to either apparatus, but the prudent surgeon will abstain from promising complete success.

It appears that in an analogous case, Tyrrell succeeded in correcting the deformity and insuring coaptation, by supporting the arm upon one branch of a rectangular splint, the other branch being applied along the trunk;* this is the position recommended by Duverney, and would be a valuable resource in case of necessity.

Whatever apparatus we employ, we should not, at least in ordinary cases, leave it on for more than thirty to thirty-five days; and soon after this we should commence exercising the joint. It is prudent also, even while the apparatus is in place, to make at times passive motion of the elbow, wrist and fingers, so as not subsequently to have to combat stiffening of them.

Fractures of the cervix humeri can hardly be complicated with a wound [or, as it would be expressed in England or in the United States, be compound,] except as the effect of gunshot; although

* A. Cooper, *op. cit.*, p. 283.

M. Guérétin has reported an instance in which the wound was caused by the lower fragment piercing through the deltoid and the integuments; the patient was injured by the caving in of a gravel-bank. The purulent discharge from this wound was enormous; amputation was performed on the forty-ninth day, and death ensued on the sixty-third. It is remarkable that the amputation was intended and supposed to have been done through the joint, but at the autopsy the head of the bone was found in place; its end was hollowed out to the depth of about one-third of an inch, and this concave surface had been mistaken for the glenoid cavity.*

I shall say but a few words concerning the separation of the epiphysis, which in young subjects sometimes occurs instead of fracture of the cervix. I have elsewhere mentioned (p. 69 *et seq.*) all the cases known to the profession; there are only four or five, showing how rare this lesion is; moreover, in the only specimen to be found in our museums, and which is represented in *Fig.* 4, there is a slight accompanying fracture. The causes are violent tractions, or falls; never, at least hitherto, direct blows. The symptoms are the same as those of transverse fractures, so that there is always some doubt as to the diagnosis in the living subject. A very peculiar result, observed by Bertrandi and by Chapelain-Durocher, was the fusion of the cartilaginous epiphysis with the glenoid cavity; so that in place of a cavity the scapula presented a rounded articular eminence, received into a new cavity hollowed out in the extremity of the diaphysis. In Chapelain-Durocher's patient, the disjunction occurred during birth, and the child lived only fourteen months; the body of the humerus was shortened by one-quarter, and the muscles of the shoulder notably atrophied. A still more marked paralysis of the arm resulted in the patient observed by me, whose age was fifty-seven years; and yet the epiphysis and diaphysis were firmly united. These cases should be carefully noted, but owing to their small number we are not warranted in drawing any general conclusions from them.

§ II.—*Intra-Capsular Fractures, or those of the Head of the Bone.*

Fractures of the head of the humerus are much more rare than those of the cervix; they present several varieties.

In *Fig.* 23, there is seen, among other fractures, a transverse fissure of the head, penetrating to a depth of more than two-thirds of an inch. An autopsy alone could reveal the existence of such a lesion as this.

There are several cases reported of fractures entirely within the

* *Presse Médicale*, 1837, p. 84.

joint, and which all, curiously enough, have separated the bone through its anatomical neck. Boyer states that he has seen several cases; and death was the unfailing result. In those cases which survived the longest, and especially in a woman who died on the seventh day, the head of the bone had undergone a remarkable wasting, being reduced so as just to fit the glenoid cavity. The same author states that the upper fragment does not at all contribute to the work of reunion. It is evident that if the head were absolutely separated from the rest of the bone, it could not in any way be reunited to it; but if the periosteum of the anatomical neck remains entire over the fracture, consolidation may become complete; M. J. Cloquet has exhibited a fracture of this kind occurring just between the head and the tuberosities, perfectly united, although with slight deformity.*

These fractures, limited to the anatomical neck, may be detected by the presence of crepitation, but are with difficulty distinguished from others, if there is little or no displacement. The only great displacement which has been observed consists in an actual luxation of the head through the capsule, either forward or backward, the neck of the bone remaining applied against the glenoid cavity; to this I shall recur in connection with luxations.

Most commonly, fracture of the head is combined with that of the neck; and it is at once intra and extra-capsular. In all these cases the cause is a direct blow; generally a fall on the shoulder. But the phenomena are various, according to the violence and to the mode of action of the fracturing cause; hence result two principal forms.

In the first, sometimes the fracture, following the direction of the anatomical neck, on one side enters the capsule and on the other remains outside of it; thus Bichat saw the humerus of a young man of seventeen, in which the head was separated from the shaft by a division which involved somewhat also the upper portion of the tuberosities; and such would seem to me to be the nature of the two cases figured by Reichel under the very inaccurate name of *epiphyseal detachments*. Sometimes there is a transverse or comminuted fracture of the cervix; or, again, a second fracture penetrating within the capsule and dividing the head into two parts; this seems to me to have occurred in the specimens represented in *Figs.* 28, 29, 31 and 32.

We find therefore, whether during life or after death, on the one hand all the symptoms of fracture of the cervix, and on the other, some which are peculiar to that of the head of the bone. This is especially set forth in *Figs.* 31 and 32, which represent the same specimen. In *Fig.* 32, the greater tuberosity is seen to be carried

* *Bulletins de la Faculté*, 1820, p. 25.

upward and inward, the head inclined inward and downward, and the inner wall of the diaphysis interlocked with the spongy tissue of the other fragment, almost as in *Fig.* 30; here are all the symptoms of fracture of the cervix merely, except shortening to about a millimètre and a half. But *Fig.* 31, a posterior view of the same preparation, shows the roundness of the head of the bone altered by two squamous projections, manifestly two fragments improperly united, and rising two or three millimètres from the rest of the articular surface.

Here the fracture of the head of the bone was behind; *Fig.* 28 shows one in front, having the characteristics of fracture of the neck, the head inclined inward and downward, together with those of fracture of the head, the detached fragment projecting forward. *Fig.* 29, by a peculiar section, shows how deeply the two fragments have penetrated one another, and that the outer one passes the surface of the other above and in front by four to six millimètres. There was no appreciable shortening.

During life, therefore, the signs will be at first those of ordinary fracture of the cervix, except perhaps more marked crepitation, the fragments being in greater number; but there is besides a widening of the head of the bone, mainly revealed by an abnormal prominence anteriorly, below the coracoid process. Sometimes this prominence corresponds to a depression below the posterior angle of the acromion; sometimes also the shoulder seems a little flattened. In some cases the prominence in front is wanting, and is replaced by one posteriorly; and finally these prominences may both be absent, or so slight as not to be perceptible during life. We see therefore that we should often be likely to confound these fractures with those of the cervix, but just in those cases in which the error would be of the least importance; the only means of arriving at a precise diagnosis is to detect some deformity [or mal-position] of the head of the bone.

We must however guard against another error, and not confound a fracture with a luxation. A woman aged 82 fell down on her left shoulder; a good deal of swelling ensued, almost preventing the acromion from being felt; another prominence was detected in the axilla; the elbow was carried outward, and the arm shortened by half an inch. A luxation was diagnosed, and the axillary prominence was actually caused to disappear by attempts at reduction. But the patient dying on the eleventh day, there was found a fracture of the cervix humeri, with separation of the head of the bone into three fragments, held together by the uninjured periosteum and capsule.

The shortening of the arm, the slight depth of the sub-acromial depression, and lastly the crepitation, form the chief grounds of the differential diagnosis.

The treatment is the same as for other fractures of the cervix; only we should seek to replace, by means of proper traction and pressure, any fragments which project either before or behind. Consolidation occupies a somewhat longer time, because of the less vitality of the upper fragment; sometimes even when there is great separation outwardly between the fragments, as in Reichel's two cases, the callus remains in great part merely fibrous. We must also generally expect more stiffening of the joint, either from the irritation necessarily occurring in it, or from the changed relations of the fragments.

In the form just alluded to, the head remains permanently projecting inward from the diaphysis, and commonly its natural prominence in this direction is increased. In the other form, on the contrary, the head of the bone is at once crushed and thrown outward, as if the external violence, after acting upon it, continued to act on the diaphysis, driving it inward.

Fig. 26 represents a fracture of this kind. The tuberosities, separated at once from the head and shaft of the bone, are divided into three fragments held together by the periosteum, but evidently displaced outward. The head, nearly separated from the anatomical neck, and partly crushed, has been turned in the same direction; its lower edge is partly lodged in the medullary canal, and the rest projects back of the diaphysis, the edge of the wall of which has deeply penetrated it. The diaphysis, carried upward and inward, is in contact with the lower portion of the glenoid cavity. The capsule, however, remains intact, being only stripped off within and posteriorly, along with the periosteum, to the extent of one or two centimètres; it was divided intentionally, so as to display the fracture.

Fig. 27 represents a similar lesion, but in a humerus isolated and stripped of all the soft parts; it shows clearly what the preceding figure left obscure. The crushing is perhaps a little less; but the outward displacement is more marked, and the diaphysis makes a more considerable projection inward. The curved dotted line shows the normal prominence of the head of the bone, and shows better the extent of the combined crushing and displacement.

In a still more marked case, the tuberosities are entirely separated from the rest of the bone, and the head applied like a cap over the upper end of the diaphysis. I have before me a drawing of such a fracture, sent me by M. Thierry.

What is the final result of such a lesion? Most commonly death ensues, not so much from the fracture itself as from the concomitant injuries due to the external violence; in the three specimens first spoken of, the fractures were quite recent, and I presume that in the cases of fracture of the anatomical neck spoken of by Boyer, there was an equal degree of crushing. All the patients, however,

do not succumb; but as to this point our information is excessively scanty.

In the Musée Dupuytren, (No. 78,) may be seen a humerus enormously flattened in its upper fourth, with obliteration of the medullary canal, distortion of the neck of the bone, and in place of the head a corrugated, nearly flat surface; so that I should suppose crushing of all these parts had occurred, with separation of the head from the anatomical neck and the formation of a false joint between the fragments. But the want of all particulars, and the loss of the scapula and of the fragment which if this conjecture be right should represent the head of the bone, have prevented my having this specimen sketched.

Another specimen (No. 79,) shows a crushing analogous to those I have had represented; there is a commencement of callus; but it is far from being completed, and death probably took place in a few weeks.

Lastly, Sir Astley Cooper has given an account of a patient who survived his accident two months. In consequence of a severe fall, the shoulder swelled enormously; a depression was however thought to be detected *in the belly* of the deltoid, and a tumor above the coracoid process; a distinct crepitus was heard, and ascribed to fracture of this process; the arm was shortened one inch. It would seem that luxation was suspected; traction was therefore made, and the bones replaced without much difficulty. The swelling gradually went down, and at the end of some weeks it was seen that the shoulder was flattened, and that a large hard tumor occupied the place of the coracoid apophysis. The slightest movement caused intense pain. About the fifth week passive motion was tried; and in three weeks the arm had recovered considerable mobility, but still it could not be raised above the level of the shoulder, or carried forward across the chest. An apoplectic attack destroyed life at about the sixty-second day.

The autopsy, which is very badly described, is happily eked out by the drawing. There was a fracture of the acromion, and another of the coracoid process, both united by fibrous tissue. The head of the humerus, broken off through the anatomical neck, with a portion of the tuberosities attached, would seem from the drawing to have been turned outward and laid upon the extremity of the diaphysis, as in M. Thierry's case; and the callus was begun at once in the interior by the spongy tissue, and at the outside by a considerable quantity of ossifiable matter deposited by the periosteum.

We can understand why union should occur in all cases in which the fracture, descending below the capsule, leaves to the head of the bone its connection with the periosteum; when it is otherwise, the head acts as a foreign body; but facts are wanting to show how nature would get rid of it, if such a thing were possible.

[An excellent article on the whole subject of this and the preceding section, may be found in R. W. Smith's "Treatise on Fractures in the Vicinity of Joints, etc.;" a case related there, (ed. of 1854, p. 201,) is remarkably similar to one treated in the Pennsylvania Hospital in 1855.]

§ III.—*Fractures of the Shaft of the Humerus.*

The most usual causes of these fractures are such as act directly upon the bone; as a blow with a stick, a fall, the arm striking some prominent object, the passage of a carriage-wheel over the limb, etc. More rarely, the bone is broken indirectly, as by a fall on the wrist or elbow. Finally, there are some exceptional cases in which muscular action has a large share, and the mechanism of which demands serious study.

Sometimes two persons want to test their strength of wrist. They place themselves facing one another, their elbows resting on a solid plane, their forearms touching by their ulnar margins, their fingers interlocked, and in this position each tries to turn outward the wrist and forearm of his opponent. In this struggle, there is first of all strong contraction of the flexors of the fingers, to resist extension, and of the pronators, to resist supination, and it is to be remarked that these muscles are mostly inserted into the epitrochlea. If they fix the forearm firmly, the turning can only be accomplished by rotation outward of the humerus; to prevent this, the muscles of the arm, and especially the latissimus dorsi, pectoralis major and deltoid, are thrown into powerful action; if their resistance is not overcome, all the efforts of the opponent will tend to twist the humerus, at some point between the epitrochlea and the insertion of the deltoid. Debeaumarchef read to the *Académie de Chirurgie*, in 1791, the first account known of fracture of the humerus by such a cause; M. Caffort addressed a similar observation to the *Académie de Médecine*, in 1827;* Lonsdale reports two others, and I myself quite recently saw another. The fracture is generally seated two or three inches above the condyles; and according to the above account of its mechanism, it would seem to be the result of torsion.

In other cases it seems to be caused by the effort of throwing a stone, a snow-ball, or some other projectile. There have been a good many such instances, at all periods of life except old age. M. Baffos saw the humerus broken in this way in a young child; Chevalier, in a young man of seventeen; Dupuytren, at twenty-three; Jacquemin, at thirty-one; Bottentuit, Nicod and Guthrie, in

* Debeaumarchef, *Journal de Méd. de Sédillot*, tome xxii, p. 384; Caffort, *Arch. Gén. de Médecine*, tome xv, p. 130.

adults.* Double has given a quite ingenious theory as to these fractures; he attributes them to the projectile force given to the lower part of the arm, while the deltoid holds back the upper portion; just as we break a stick by holding it firmly by one end and violently beating the air with the other.† If this be so, the humerus should give way below the insertion of the deltoid; now in Bottentuit's and Dupuytren's cases, the fracture was seated near the junction of the middle and lower thirds of the bone; Nicod saw it a little above the middle, and Chevalier, Jacquemin and Guthrie saw it just at the insertion of the deltoid. The theory of Double is therefore quite sustained by experience; the fracture seems due here to forcible flexion of the bone.

Other movements and efforts may likewise result in fracture of the humerus. Manne relates the case of a soldier who broke it at the lower part in trying to throw a ball to a great distance; and Seaton saw the same thing in a man of forty-six who had tried to knock back a tennis-ball.‡ In a case cited by Lonsdale, the cause was a blow which the patient gave with his fist; the bone was broken at the junction of the middle and lower third. A man slipping, and trying to keep up, stretched out his hand against a wall which was close by; the humerus gave way near the insertion of the deltoid. Another broke his at the same point by putting out his arm between two persons to separate them.§ Probably in these different cases the mechanism was very much the same as that pointed out by Double. Since however the fracture may take place at very various points, we must recall what was elsewhere shown, viz., that most generally these almost spontaneous fractures are preceded by a subinflammation of a circumscribed portion of the bone, which is thus disposed to give way. It would otherwise be especially difficult to comprehend the case related by Liston of a woman, who broke the humerus by stretching out her arm to seize a child with which she was playing; and a similar case in which the fracture resulted from a slight effort in lifting a basket of grapes. M. Goyrand expressly states that the patient had long been subject to severe and deep-seated pains in the arm.‖

* Baffos, *Archiv. Gén. de Médecine*, tome xxi, p. 449; Chevalier, *Journal de Boyer*, tome xx, p. 276; Dupuytren, *Gazette des Hôpitaux*, 1833, p. 29; Jacquemin, *Recueil de Mémoires de Médecine, Chir., et Ph. Militaires*, tome vii, p. 245; Bottentuit, *Journal de Sédillot*, tome xxiv, p. 375; Nicod, *Annuaire des Hôpitaux*, 1819, p. 496; Guthrie, *American Journal*, August, 1835, p. 524.

† *Journal de Sédillot*, tome xxiv, p. 376.

‡ Manne, *Journal de Sédillot*, tome xxiii, p. 265; Seaton, *American Journal*, Feb., 1836, p. 512.

§ Kuttinger, *Recueil de Mém. de Méd., Chir., et Ph. Militaires*, tome viii, p. 258.

‖ Liston, *American Journal*, Nov., 1836, p. 249; Goyrand, *Gazette des Hôpitaux*, 1836, p. 477.

An entirely different mechanism must be admitted, however, for the singular case briefly reported by Larrey to the *Académie de Médecine*. A lady alighting from a carriage, and feeling the step give way beneath her, grasped strongly the handle of the coach-door; the humerus was thus fractured just above the deltoid.* It would seem that here the deltoid tended to draw up the lower portion of the bone, while its upper portion was drawn downward by the pectoralis major, teres major, and latissimus dorsi.

Lastly, Volcamer has related an instance of this fracture in a boy of ten, from muscular contraction during an epileptic fit; but perhaps this observation is not perfectly satisfactory.†

Aside from these special causes affecting certain points, the humerus may be fractured anywhere in its extent. Sometimes the fracture is incomplete, as Jurine and Hart would seem to have observed it; but this is very rarely the case. More commonly the fracture is serrated, without any great injury to the periosteum; and the fragments, mutually interlocked, cannot be moved upon one another, and hence give no crepitation. Raleigh saw a fracture of this kind in a child nine years old, which had fallen out of bed; for eight days no sign of fracture was detected by the surgeon; on the ninth, perceiving that the humerus bent toward its middle, he diagnosed an incomplete fracture.‡ I have seen an entirely similar case in a child of fifteen months, and another in a girl of fourteen years; the fracture is quite complete, but it gives hardly any sign of its existence except this unnatural flexibility of the bone.

It is to be remarked that in most fractures from muscular action, the fragments remain in contact, without any displacement. Dupuytren's patient forms, however, a remarkable exception to this rule; in his case the fragments were entirely disjoined, and so movable that consolidation could not be obtained; resection had to be performed three months afterwards.

But in fractures from ordinary causes, it is far more common to meet with more or less considerable displacements, varying according to the direction of the blow, and especially to that of the fracture. *Fig.* 35 represents a double fracture; the upper fragment is displaced outward from the middle one, and this again in front of the lower one. The section of the same specimen, *Fig.* 36, shows at once these displacements and the overlapping consequent upon them. *Fig.* 37 represents a simple fracture, with a splinter detached from the anterior wall of the bone. The two ends of this wall have been replaced in contact, and yet the lower fragment projects notably backward and upward; this is due to the formation by the two fragments of an angle opening anteriorly. *Fig.* 38 shows a fracture

* *Archiv. Gén. de Médecine*, tome xv, p. 130.
† *Ephem. Nat. Curios.*, decade i, an ii, obs. 225.
‡ *American Journal*, Feb., 1836, p. 512.

running obliquely downward, inward and forward; the displacement has occurred in the same direction. *Fig.* 39 shows a fracture obliquely downward and inward; the displacement is in the same direction, but here there is moreover an angle opening internally. Finally, in *Fig.* 40 we see a fracture downward and backward; the lower fragment rides up in front of the other, with which it forms a very marked angle anteriorly.

I might multiply these examples; but it suffices to examine the specimens displayed in our museums, to perceive that these displacements are governed by no general law, except that of the direction of the fracture. When the fracture is nearly transverse, and comminuted; when the injury done to the soft parts has destroyed nearly all connection between the fragments, then only can these latter yield to the muscles acting upon them; and the deltoid tends to raise outward the fragment into which it is inserted. But in most cases the action of the muscles is limited to the production and maintenance of overlapping.

To the causes already enumerated must, however, be added one more, of too great importance to be passed over, viz., improper treatment; to this are chiefly due angular deformities forward, inward or backward.

The phenomena of fractures of the humerus are *par excellence* those of fractures of the long bones; pain, loss of power in the arm, bending of the bone, mobility of the fragments in various directions; prominences, deformity and shortening, resulting from the different displacements; and lastly, crepitation. In general, serrated fractures without displacement do not give rise to any appreciable amount of swelling; I would, however, remark that in one of the cases resulting from throwing a stone, that of Guthrie, the arm was attacked by phlegmonous inflammation and suppuration. In another case of the same kind, that of Nicod, an abscess formed at the seat of fracture, after more than fifty days, and when the callus was already consolidated; some small splinters escaped, and after that the cure was rapid and complete.

But when the external violence has been severe enough to disjoin the fragments, there is no other fracture which is so often followed by inflammatory swelling as that of the humerus; and the imminent danger of this complication should constantly engage the attention of the surgeon.

The diagnosis offers no serious difficulty as to the fracture itself; but the swelling very often makes it impossible to determine exactly the extent, or even the direction of the displacement.

The prognosis is by no means grave when the fracture is simple, and without displacement; twenty-five or thirty days suffice for consolidation in young subjects, and in adults, from thirty-five to forty days. When the displacement occurs only in the thickness of the

bone, it may be easily overcome, and all will go on well. But when there is great obliquity and overlapping, or a splintered or multiple fracture, some deformity is inevitable, and the callus will be a week or two longer in forming. Along with inflammation comes the danger of suppuration, and of subsequent stiffening of the joints, which it is hard to remedy. Finally, it should not be forgotten that of all fractures, those of the humerus are most liable to non-union.

Reduction should be made in the same position in which the injured limb is to be kept. If the patient can sit up without inconvenience, the forearm should be flexed at a right angle, in front of the chest, the elbow close to the body; if circumstances require him to keep his bed, the forearm should be laid upon cushions, and hence a somewhat obtuse angle will be better. One assistant raises the forearm and hand; another grasps the shoulder with both hands, to make counter-extension; a third draws down the flexed forearm or the condyles of the humerus, to make extension; while the surgeon, standing on the outer side, attempts coaptation. First of all we must be assured that the epicondyle is in the same line with the insertion of the deltoid, and with the most prominent part of the shoulder; and then that the arm has regained its natural form, length, and thickness; but I cannot sufficiently warn the young surgeon that simple as may be the displacement, the coaptation will never be absolutely perfect.

All sorts of apparatuses have been tried in these fractures; splints, immovable and plaster apparatuses, cuirasses, cushions, boards, troughs, and contrivances for making permanent extension. In studying the indications followed, we see that at first, the mere keeping in contact of the two fragments was aimed at, without any attempt at fixing firmly the articulations above and below; such is the object of the ordinary splints.

Afterwards such immobility was sought for the elbow, as in Amesbury's and the immovable apparatus.

Then the immobility was extended to the shoulder, as in the apparatus of M. Bonnet, of Lyons.

Then overlapping was combated by means of permanent extension.

And finally, in compound fractures, facility of dressing has been provided for in the hyponarthecic apparatus.

The ordinary splints date back as far as Hippocrates; I shall merely describe Boyer's method of applying them. First, even before making any attempt at reduction, he enveloped with a roller the hand and forearm; then, the reduction being made, either with the same bandage or with another he covered up the arm from below upward, carefully filling the hollow at the insertion of the deltoid with charpie or cotton, and making three or four circular turns just over the fracture. This done, he surrounded the limb with three or four splints, according to its size. When four splints seemed requisite,

one was put on the outside, one on the inside, one in front, and one behind, their length being adapted to that of the different sides of the arm; when three answered the purpose, the inside one was left off. These splints were made either of thin slips of wood, or of tin; for young subjects, even of mere pasteboard. They were held in place by an assistant, until fastened by turns of a bandage, with which the arm was completely enveloped. The arm was then fastened to the side, the forearm being held in a sling; and circular turns were made to surround the trunk and arm together, so as to render the arm entirely immovable.

Some modern surgeons postpone bandaging the forearm until after reduction, and put no circular turns over the sling. Boyer's plan was better calculated to preserve the coaptation; and he remarks very justly that if we employ the sling only, the wrist and forearm may be carried backward and forward, thus giving the lower fragment a rotary movement. However, even with this precaution, Boyer could not prevent some slight flexion of the elbow; Amesbury sought to guard against this.

Amesbury's apparatus was composed of (1) two beech-wood splints fixed firmly at a right angle, so as to fit the anterior face of the arm and the superior face of the forearm; (2) of another beech-wood splint merely covering the posterior face of the arm down as far as the elbow; (3) of two common deal splints for the sides of the arm; the whole to be fastened together by means of five straps with buckles. He commenced, like Boyer, by enveloping the limb with a roller, from the wrist up to the shoulder; he carefully padded each splint; and lastly, he supported the forearm in a sling.

The immovable apparatuses attain the same end with less trouble. The simplest is doubtless that of M. Velpeau. A piece of dry linen being first spread over the skin, a dextrinated roller is applied from the hand up to the shoulder, and fixed above by a few turns of the spica over the shoulder. Commonly two or three layers of the dextrinated bandage are sufficient; it is only in exceptional cases that M. Velpeau adds two sheets of pasteboard, or graduated compresses.

This dressing would seem calculated to make the shoulder perfectly immovable; but not so efficiently as the *cuirasse* of M. Bonnet, of Lyons.

This is made of a cuirass covering half the chest, before and behind, to which is attached a splint, hollow anteriorly, directed downward and outward so as to receive the arm, and continuous with another one which is horizontal, for the forearm and hand. The basis of this apparatus is iron wire, making it at once firm and light; but it is carefully padded, and covered with chamois-leather. The upper splint, hollowed in front to receive the arm, is fastened by circular straps; so that the fracture may be examined, and the pressure increased or lessened, without disturbing the arm at all; and as this

splint is a mere appendage of the one around the chest, all the patient's movements are movements in totality, and he can sit up, rise, etc., without the motions of the trunk occasioning the slightest displacement in the fracture.*

Let us test this in the simplest fractures, without overlapping, inflammation, or external wound. In such a condition of things, unless there is excessive mobility of the fragments, the body-piece proposed by M. Bonnet may seem superfluous; Amesbury's apparatus, in spite of its complication, does not insure perfect immobility; and that of M. Velpeau, although very simple, has the inconvenience of concealing the parts. Therefore I would in ordinary cases prefer common splints; even Boyer's apparatus might, it seems to me, be brought into a much simpler form.

I have elsewhere mentioned (p. 170 *et seq.*) what should be thought of the roller improperly applied over the hand and forearm. I limit my application of the bandage and splints to the arm itself; when there is danger of swelling and inflammation, I leave off the roller entirely, and apply the splints to the skin, only with compresses of equal width beneath them. These splints, confined by means of two or three strips of diachylon, do not tend to become deranged, and their interspaces enable me to keep the state of the limb always in view.

For the rest, the sling suffices to support the forearm when the fracture is without displacement; otherwise the arm must be more firmly fastened to the body. But with the circular turns used by Boyer, or with the ordinary body-bandage, there is one danger to which attention has not been called. In the healthy state, when the forearm is applied to the chest, the epitrochlea remains separated from the trunk; and if in case of fracture our circular turns tend to bring the two together, they can only succeed by making the two fragments form a more or less marked angle. Hippocrates would seem to have had this in view when he recommended putting a thick linen compress between the elbow and the ribs. I cannot rest satisfied with this, but employ a quilted cushion, thicker below than above, and reaching from the armpit to the elbow, so as at once to afford the arm a more equable support than the ribs would, and to keep the epitrochlea apart from the body. However tractable the displacement may be, I substitute for the sling a hollow pasteboard splint to support the forearm and hand, embracing also the lower portion of the arm.

Other difficulties present themselves when there is overlapping to a greater or less degree. J. L. Petit advises us then to tie the sling more loosely, so as to allow the arm to hang a little, hoping in this way to counterpoise the muscular contraction; but the weight is too

* *Bulletin de Thérapeutique*, tome xviii, p. 180.

small to have such an effect. M. Petrequin told me he had tried suspending a weight to the forearm during the day, and during the night replacing it by two loops, one in the axilla and the other at the elbow, fastened respectively to the head and foot of the bed. M. Bonnet would attain the same end with his cuirass, drawing the whole down by means of thigh-pieces; but he has omitted to say how he would make his counter-extension. Finally, I have described, in connection with fractures of the cervix humeri, the contrivances of MM. Coillot and Gély, which may be as properly applied in fractures of the shaft; there remains to be mentioned the one devised by Lonsdale.

This is an iron splint about four centimètres in width, long enough to reach from the axilla to below the elbow. Its lower end curves under the elbow, as if to embrace it, and ends in a sort of hook to give attachment to a bandage; for the same purpose the body of the splint presents two small lateral projections opposite to and at the same level with this hook. The other end of the splint has a crutch-head, movable up and down, and fixed at the required height by a screw. This crutch-head being put in the axilla, the elbow engaged in the curve below and kept there by a bandage fastened as before mentioned, extension is made by drawing one way on the elbow, and the other on the crutch-head; when the arm regains its natural length, the only thing to be done is to fasten the screw. It is unnecessary to say that we must very carefully protect the parts pressed upon, in order to prevent sloughing.

[The plan generally adopted in Philadelphia is the same as that mentioned for fractures of the cervix; except that the pasteboard cap is here useless, unless it be to better confine the shoulder; but at any rate it is well to apply a pasteboard splint on the outside of the arm. The advantage of the inside angular splint, which should extend well up into the axilla, is that we have along the inside of the arm a fair chance at the bone, which is there almost subcutaneous. Very excellent results have followed this mode of treatment.]

I have nothing to add touching the choice of these various methods. The surgeon should never forget that permanent extension is always dangerous, and needs great caution and watchfulness in its application.

When the fracture is attended with high inflammation, or when it is compound, the patient should be put to bed, and the injured limb supported on cushions, the forearm at an obtuse angle with the arm; the elbow should be on a level with the shoulder, the hand a little higher than the elbow. No bandage should be applied, but support may be given by means of two lateral splints. We must then enjoin upon the patient great quietness, in order that the upper fragment may be undisturbed by any movements of the head, trunk, or shoulder. To insure this is very difficult; hence consolidation is often greatly retarded, especially when an external wound communicates

with the seat of fracture. It is in cases of this kind that the *cuirasse* of M. Bonnet has seemed to me to be of great use, after the subsidence of the inflammatory symptoms.

When consolidation is long delayed, we must not forget, while fixing the fragments as firmly as possible, to make passive motion of the shoulder, and particularly of the elbow-joint. [Dr. Christopher Johnston, of Baltimore, recently informed me that in 1852, while following Langenbeck's practice in Berlin, he saw an instrument used by Professor L. in a case of delayed union after fracture of the humerus, acting on the same principle as that devised by M. Malgaigne for fractures of the patella; the result was favorable.] As to articular stiffening, and other consecutive symptoms, I refer the reader to the remarks made in connection with fractures generally.

§ IV.—*Fractures of the Humerus above the Condyles.*

I give this name to what Dupuytren called *fracture of the lower extremity of the humerus*,* in order to make our language more precise. It is, then, a solution of continuity, separating the whole articular extremity of the bone, without entering the joint; and in children, who are more subject to it than adults are, it is probably in many cases a disjunction of the epiphysis. I have elsewhere mentioned M. Champion's case, in which this idea was confirmed by the autopsy, (see pp. 70 and 72.)

Most commonly this lesion is the result of a fall on the elbow; although in M. Champion's patient it was caused by traction, the forearm having been caught in a carding-machine.

The symptoms are in the first place those of all fractures: pain, loss of power, swelling, crepitation, etc. Sometimes there is no displacement; the fracture is then discovered by the crepitation, which is especially elicited by twisting the forearm upon the arm. Another good plan is to try to bend the humerus backward, so as to make the two fragments form an angle salient anteriorly.

When the fragments are displaced, they generally form this very angle; the upper one remains in place, the lower one following the movement of the olecranon, which is drawn upward and backward by the triceps. Hence the antero-posterior diameter of the elbow is increased; a transverse prominence in front is due to the angle at the seat of fracture; the olecranon projects backward sometimes four or five centimètres more than that of the sound side, and passes up also along the posterior face of the arm; in a word, we have nearly all the phenomena of luxation backward. Hence mistakes have more than once been made, and the differential diagnosis demands particular attention.

* See *Leçons Orales*, tome i, p. 117; and the *Gazette Médicale*, 1833, p. 102.

What is the real direction of the fracture? Sir A. Cooper maintains that it is oblique; Dupuytren considers it transverse; and in a girl of fifteen, who died after receiving such an injury, it was clearly made out that both fragments contributed to the angle. In the case in which M. Champion made an autopsy, the age being at least thirteen, there had been separation of the epiphysis and detachment of a thin splinter of the diaphysis, which is almost equivalent to a transverse fracture. But in a specimen in the Musée Dupuytren, which manifestly came from an adult, we may see, in spite of the solidity of the callus, that the fracture was oblique downward and backward. *Fig.* 40 gives a very correct idea of the displacement. Lastly, I have seen in a little girl two years old a fracture above the condyles, of several months' standing, in which the fragments were extremely movable, forbidding all hope of union; the fracture was oblique from one side to the other, running from without inward.

To sum up, here as elsewhere, the fracture may be transverse, oblique from before backward, or oblique from one side to the other; it may exist without displacement, or may present any displacement whatever. Thus in the Musée Dupuytren there is a specimen (No. 88) of a fracture of this kind united with an angle posteriorly. When the fragments are completely disjoined, they no longer form an angle, but may overlap or twist upon one another; M. Guersant mentions a rotary displacement of the lower fragment, by which the epitrochlea was brought in front.* In the specimen represented in *Fig.* 41, to which I shall again refer in speaking of fracture of both condyles, the upper fragment descended behind the other.

Such rotation or overlapping must add to our means of diagnosis. But this is an affair of more difficulty when the injury simulates a luxation backward. Sir A. Cooper, who was the first to treat of the differential diagnosis, recommends us in the first place to try if we can detect any crepitation; and he adds that in fracture all the phenomena disappear when traction is made on the forearm, but only to reappear when this is suspended; while a luxation, when once reduced, does not recur. Dupuytren has given different directions. Grasp, says he, one fragment in each hand, the thumbs in front and over the fracture, and attempt thus to make reduction. This simple manœuvre, without any other extension, is generally sufficient, especially when the injury does not date back more than twenty-four or thirty-six hours. But the reduction being thus completely performed, push the forearm backward again; if it was a luxation, the reduction will be persistent; if there is a fracture, the displacement will immediately reappear.

These means are doubtless useful, but will not suffice in all cases. The swelling of the soft parts may render the crepitation very indis-

* *Gazette des Hôpitaux*, 1845, p. 519.

tinct, or even mask it completely. The reappearance of the displacement may occur as well in luxation with fracture of the coronoid process as in fracture of the condyles. I long ago pointed out symptoms far more strictly conclusive.* Whatever may be the projection backward of the olecranon, it is never any farther from the epicondyle and epitrochlea than in the natural condition, if the case is one of fracture; it is much more so if there is a luxation. So also, in fracture the anterior prominence is narrower and more rounded than in luxation; but moreover, it is here above the fold of the elbow, while in luxation it is far below it. Once more, on measuring the distance from the acromion to the epitrochlea, we find in the fracture a shortening which does not occur in the luxation.

The prognosis is not without gravity. I do not allude to the symptoms which may supervene, although Monteggia saw a simple fracture of this kind give rise to tetanus, which not even amputation could prevent from terminating fatally. This instance is probably unique, and does not show what we usually have to dread. But the swelling may be so great as to hinder reduction, and thus compromise the play of the elbow-joint; the mere maintenance of reduction is not easy; so that, as Sir Astley Cooper remarks, even after the most skilful treatment, the motions sometimes remain extremely impaired; and if the accident has been misunderstood or badly treated, the deformity and loss of motion may be very considerable. Lastly we must not lose sight of the danger of non-union, as in the child recently mentioned.

Reduction is performed as stated, either by drawing down the forearm, or by pushing back the angle salient anteriorly with the two thumbs, while the other fingers of the right hand, for instance, bring the olecranon downward and forward; but when the reduction is intended to be permanent, it is proper to make it in the position in which the limb is to be kept.

The position almost universally adopted in these cases since the time of Hippocrates, is semiflexion of the forearm. Boyer says however that certain surgeons, whom he does not name, proposed to extend the limb, fixing it with four splints. He thinks that this may be the most solid mode of doing up the fracture; but as such a position would soon become insupportably painful, and as, besides, anchylosis occurring with the arm straight would be particularly inconvenient, he concludes by giving the preference to semiflexion. I would not be so exclusive; and if mere extension would keep the fragments in place in a case of some difficulty, I would not hesitate to resort to it, at least in the early stages, using, however, all the necessary precautions against anchylosis.

But if reduction can be made as well in the semiflexed position,

* *Gazette Médicale*, 1834, p. 103.

this is certainly preferable. Henckel kept the arm fixed thus by means of two lateral angular splints. Boyer commenced by the application of a roller to the limb; after which he fitted over its whole length two splints of thick pasteboard, one on the surface of flexion and the other on that of extension, bent so as to suit the bend of the limb; these were notched to the extent of one-quarter of their width on each side, opposite the elbow, so as to fit better, and moistened so as to take the exact form of the limb. They were kept in place by a bandage long enough to cover the whole limb twice.

Sir Astley Cooper's apparatus was somewhat different. After the roller, he placed behind the limb a splint bent at a right angle, to maintain it in this position; then a small straight splint over the anterior face of the arm merely, the whole being confined by bands. It appears that Sir A. Cooper had in view, with his small splint, an indication overlooked by Boyer, and that he thus sought to press backward the angle of the two fragments. This however was not sufficient; the olecranon requires at the same time to be pressed forward. This was the double object proposed by Dupuytren.

Dupuytren therefore applied over the whole anterior surface of the arm graduated compresses, made somewhat thicker opposite the prominence of the fragments; other compresses were arranged posteriorly; over these were placed two splints, one anterior, pressing upon the prominence, and the other posterior, bearing on the olecranon and pushing it forward. With the same object there was added another compress placed transversely, its middle over the olecranon and its two ends crossed in front of the arm; the whole was kept in place by a roller.

Henckel's apparatus, or that of Boyer, will answer when there is no displacement, or when the displacement, once reduced, shows no tendency to recur. But when we have to strive against this disposition of the two fragments to form an angle anteriorly, we need something which will act more directly; and neither Sir Astley Cooper's anterior splint, nor Dupuytren's graduated compresses, are sufficient. I place then across the anterior face of the arm a pad two or three fingers'-breadths long, made by a compress of from eight to sixteen folds; over this pad the lower end of the anterior splint presses to much greater advantage. For a posterior splint, that of Sir A. Cooper would doubtless be the best if it were at hand, since it keeps the limb most at rest; and if we can command only an ordinary splint, we may supply its place by fitting to the arm and forearm a pasteboard trough fastened with bands. The roller beneath the splints is useless; and Dupuytren's transverse compress over the olecranon could act only momentarily. It is in the pressure on the two splints that the efficiency of the entire apparatus resides. I prefer to all other means strips of adhesive plaster, as less likely to become relaxed; one of these strips, surrounding the lower end of the posterior

splint, should have its ends crossed over the anterior one, so as to insure steady pressure over the olecranon.

[An excellent mode of treatment for all fractures of the humerus near its lower extremity, consists in the use of an angular wooden splint bandaged to the front of the arm and forearm; this should reach up to the shoulder and down to the ends of the fingers, so as to render the entire member immovable; the surface applied to the limb should be hollowed out and well padded, and if necessary a posterior splint of pasteboard may be so arranged as to aid materially in keeping the fragments in place. It is very important, in order to obviate stiffening of the joint, that the angle of the elbow should be varied from time to time; and this may be done either by providing a supply of splints of different angles, or by constructing one with a hinge between its two portions, so as to change the angle at will; a Stromeyer's screw being employed to maintain it at the desired degree. It is not necessary, perhaps not even desirable, that a bandage should be first applied to the injured member.]

The apparatus should not be removed unless some urgent symptom should arise; Dupuytren kept it on for a month. Delamotte relates one case of complete consolidation, in a boy ten years old, at the end of three weeks.* There would be some advantage, and no inconvenience, in leaving the dressing in place for the whole time advised by Dupuytren, on condition of observing another precept, laid down by Sir A. Cooper; namely, that at the end of fifteen days in young subjects, or of three weeks in adults, passive motion of the elbow should be cautiously commenced, so as to prevent anchylosis.

If we have an intractable child to treat, it would be well to follow Delamotte's plan of posting two servants by the patient night and day, to prevent any injurious movement; a precaution which would doubtless have no small influence on the rapidity and regularity of consolidation.

When a fracture of this kind has united badly, all we can do is to restore the motions of the elbow, either by exercise or by some mechanical contrivance.

§ V.—*Fractures of the Epitrochlea.*†

The history of these fractures is only of very recent date; the first work on the subject was only published in 1818.‡ They consist in a breaking off of the epitrochlea either at its point or at its base, but without at all involving the articular surface.

* Delamotte, *Traité de Chirurgie*. obs. 352.

† [The *internal condyle* of American and English anatomists.]

‡ B. Granger, *On a Particular Fracture of the Inner Condyle of the Humerus; Edinburgh Medical and Surgical Journal*, vol. xiv, p. 196.

Although the epitrochlea is much more elongated in adult age than in early life, it is almost always in children that we see it broken. Granger reports two instances observed in boys eight and eleven years old; M. Pézerat saw two others, one in a boy of twelve, and the other in a young man;* I have myself had occasion to treat such a fracture in a boy of ten. There is therefore ground for supposing that in some cases at least it is a disjunction of the epiphysis; the epitrochlea, as is well known, ossifying separately until about the age of seven years. Still this preference, as it were, for young persons, is not exclusive, and I have seen one instance occurring in a man of fifty-two.

The most common cause would seem to be a fall on the epitrochlea, the elbow being separated from the body; this was the case in M. Pézerat's two patients, and in my own; and this was especially clear in my little boy, whose elbow was driven into the gravel, leaving an impression there. Granger, however, does not admit this view of the mechanism; he thinks the fracture is the result of violent contraction of the muscles attached about the epitrochlea, as for instance when the arm is put out in falling, and the hand, touching the ground first, receives the whole weight of the body; in support of this theory he relates a case in which the patient, a child eight years old, said he had fallen on his hand. He has also seen this fracture complicated, once with a luxation of the radius, another time with a luxation of the elbow, and as these luxations, says he, are known to be produced by falls on the hand, the fracture of the epitrochlea should be referred to the same cause. This argument is essentially defective in its foundation; for, as I shall show at the proper time and place, most luxations of the elbow result from falls on the elbow itself. I do not deny that the epitrochlea may be torn off by the action of the muscles, and as a consequence of falling on the hand; but this must be very rare, and would need to be determined with much greater precision.

The symptoms vary in this as in all other fractures. In my little patient, the pain and swelling made me suspect the fracture; but the mobility was doubtful, and no crepitation was perceptible; it was not until eight days afterwards, when the swelling had subsided, that all doubt was removed by the occurrence of distinct crepitation. There was no appreciable displacement. In the man of fifty-two, before mentioned, the epitrochlea had been drawn downward to nearly the level of the articular surfaces; the muscles attached to it were somewhat in relief beneath the skin; the forearm remained flexed upon the arm and pronated; extension was very painful, and supination still more so, so that in fact it could not be completely

* Pézerat, *Obs. sur la fract. de l'épitrochlée; Journal Complémentaire*, tome xlii, p. 418.

made. In the movements of flexion and extension of the forearm, the hand placed on the epitrochlea felt a sensible crepitation; this apophysis could moreover be grasped separately and moved backward and forward.

It appears that displacement is most commonly present; it existed in both M. Pézerat's cases, and Granger notes it as constant. If so, the epitrochlea is always carried downward; but Granger adds that sometimes its position varies, it being found now in contact with the olecranon, and again an inch or even more in front of it.

Granger saw also in one or two cases ecchymosis extending along the inner border of the forearm, which would seem to me a plain indication of a direct blow upon this part. Neither M. Pézerat nor myself have met with anything but very moderate pain and swelling. Granger was less fortunate; it appears that in all his cases he had to combat very high inflammation of the elbow and forearm, extending to the termination of the fleshy fibres of the muscles attached to the epitrochlea, and inducing such swelling as almost entirely to prevent the motions of the elbow.

Such inflammation could hardly result from anything but the extreme violence of the cause of the fracture; and the displacement, kept up by the muscular irritation, would then resist all our efforts at reduction. Hence there is deformity, not produced merely by the drawing down of the fragment, but also and chiefly by the shrinking of the muscles attached to it. The inflammation of the elbow inevitably brings on also most obstinate stiffening of the joint, to such a degree that in the first case he examined, Granger feared for some time that incurable anchylosis would ensue. Lastly the ulnar nerve, passing between the olecranon and the epitrochlea, is also sometimes injured, either, as I think, by the direct blow, or according to Granger's view, by the pressure to which it is subjected in the displacement of the epitrochlea. He cites a remarkable case of this.

It was in the child eight years old, who said he had fallen on his hand. The inflammation was violent, the stiffness of the elbow obstinate; still, in less than three months after the accident the child had recovered the free and complete use of the joint, but the ulnar nerve remained paralysed. From the moment of the injury, the little finger, the ulnar side of the ring-finger, and the integuments of the ulnar side of the hand, had lost all sensation. The abductor of the little finger, and the two adjacent muscles (the short flexor and the adductor) were paralysed. Some weeks after the accident, an eruption of small vesicles appeared on the little finger and ulnar edge of the hand, and lasted two or three months. In the course of a few years, exercise restored gradually not only the muscular power, but also the sensibility of the skin; and at the end of seventeen years there remained only some uneasiness after excessive use

of the arm at the point where the displaced fragment had become adherent, and temporary numbness of the little finger when it was strongly compressed.

Granger observed the same phenomena, namely the paralysis and the vesicular eruption, following the same fracture in two other patients.

The diagnosis is easy, except when the swelling prevents us from grasping and moving the detached fragment.

The prognosis is very favorable as regards the fracture itself; if there is little or no displacement, consolidation occurs regularly in twenty-five or thirty days; if the displacement is considerable and cannot be reduced, there is involved merely a slight deformity and a temporary hindrance to the play of the muscles of the forearm. But it must be recollected that stiffening of the joint is almost inevitable; in my little patient, notwithstanding the slight grade of the inflammation, the angle of the elbow could only be varied between 80° and 140° after two months and a half had elapsed.

As to treatment, Granger merely kept the forearm in the semiflexed position, rejecting all apparatus as not only useless, but hurtful by preventing the continual exercising of the joint, which in his opinion constitutes one of the principal indications. Pézerat prefers strong extension, with the view of relaxing the extensor muscles. This is an anatomical error, since it is the flexors which are attached to the epitrochlea, and hence there is a real advantage in flexing not only the forearm, but also the hand and fingers. If this position does not suffice to restore the detached fragment to its place, I doubt if any apparatus could keep it there; however there might be some advantage in trying it, if we only came somewhere near our aim; and if there be any displacement forward or backward, as has been seen by Granger, it would be easy to remedy it. I think also, notwithstanding his views, that it is important to insure consolidation, without however overlooking the danger of anchylosis. In the two cases I had occasion to treat, the forearm being semiflexed, I placed in front of the epitrochlea several pieces of agaric, with the double object of protecting it from pressure and pushing it backward; I surrounded the elbow with a dextrinated bandage, and being careful to move the joint at about the fifteenth or twentieth day, I obtained in both cases regular consolidation, without much stiffening. Granger himself declares that of five patients treated by him four recovered completely the motions of the elbow; and if the fifth lost them somewhat, it was because his fracture had been complicated with luxation.

CHAPTER XII.

FRACTURES OF THE ELBOW.

I GIVE this name to all fractures which pass into the articulation. I shall treat in succession: (1) of fracture of both condyles of the humerus; (2) of fracture of the external condyle; (3) of fracture of the trochlea or inner condyle; (4) of fracture of the olecranon; (5) of comminuted fracture of the elbow. Fracture of the coronoid process is generally attended with luxation of the ulna, and I shall postpone its consideration until I come to treat of that luxation.

§ I.—*Fractures of both Condyles of the Humerus.*

It was, if I mistake not, Desault who first called attention to this fracture, which would seem a very rare one; for up to the present time I have only been able to collect eight cases, four simple, and four with the complication of an external wound.* It is a combination of a fracture above the condyles with another running more or less vertically, separating the two condyles and thus making three fragments.

The only cause alleged is a fall on the elbow, this being sometimes close to the body, and sometimes apart from it. This fracture has been observed both in men and in women; the age of the patients has varied from eighteen to forty-one years. Its seat is not always the same. In a case communicated by Ivimy to Sir A. Cooper, the bone was broken across two inches and a half above the condyles; in another case, published by M. Ruyer, in its inferior fourth; lastly, in a specimen sent me by M. Huguier, represented in *Fig.* 41, the fracture is not more than a few millimètres above the outer condyle, nor more than two centimètres above the inner one.

In this latter case the other fracture is very nearly vertical, and passes through the middle of the articular surface. Is it so also

* See for the simple fractures, Desault, *Journal de Chir.*, tome iv, p. 163; Ruyer, *Revue Médicale*, March, 1834; *Goyrand, Traité de pathol. externe*, by Vidal, tome ii, p. 109; Huguier, *Thèse de Concours*, 1842, pp. 26 and 30. Of the four compound fractures, three are reported by Sir A. Cooper, and one by Lonsdale.

when the transverse branch is as high up as seen by Ivimy and M. Ruyer? Have we not then rather an oblique fracture separating one condyle from the rest of the bone, as in several forms just described, with a transverse fracture of the body of the bone entirely independent of the first? We need further facts in order to answer this question.

The phenomena are those of fracture above the condyles, combined with those of separation of the condyles; and they are moreover very variable. Desault noted in his patient a considerable swelling around the elbow, and severe pain, especially in flexing and extending the forearm. The transverse fracture of the body of the bone has been recognised by the deformity of the part, by its preternatural mobility, and by crepitation; as to the vertical fracture, by grasping one condyle in each hand, we can move them upon one another, eliciting distinct crepitation. M. Ruyer speaks also of swelling, deformity, and double crepitation; he adds that the forearm was semiflexed and pronated; and in moving the two condyles in opposite directions he took the precaution of having the upper fragment steadied by an assistant.

The nature of the deformity is not indicated; probably the lower fragment was drawn upward and backward, and the elbow widened by the separation of the condyles. But M. Huguier has noted another kind of displacement, which I was unwilling to have represented in the figure, since it would have obscured the direction of the two fractures; it is however easily explained when we consider the division of the bone obliquely downward and backward in the upper fracture.

There was an overlapping of fifteen to eighteen millimètres. The lower end of the upper fragment, carried downward and backward, came to rest upon the summit of the olecranon, in front of the tendon of the triceps, thus by its own projection lessening the normal prominence of the olecranon; besides which, its lateral angles formed two small sharp points on each side of the tendon. The two lower fragments had ridden up forward, carrying along with them the bones of the forearm, and formed above the bend of the elbow a slight transverse prominence, limited on each side by the lower tuberosities of the humerus. The forearm was in a state of nearly complete extension; the tendons of the biceps and brachialis anticus were midway between relaxation and tension; the mobility was considerable, and the crepitation very easily produced, as was also the reduction.

It is to be regretted that Sir A. Cooper has been silent concerning the phenomena presented in his cases of compound fracture. In one case, Ivimy noted only that the bone forming the greater sigmoid cavity was broken into several pieces, three of which were extracted through the wound. It may be seen from *Fig.* 41, that in M. Huguier's

patient the cavity for the olecranon has lost a portion of its wall; and another fracture, vertical but incomplete, may be seen dividing the inner fragment. In another case Sir A. Cooper says that a portion of the inner condyle protruded through the integuments.

The diagnosis of this fracture has been already marked out in the description of its symptoms. The prognosis, in simple cases, is not very grave. Desault's patient was discharged from the Hôtel-Dieu on the thirty-seventh day, with the fracture well consolidated, and with already very extensive motion of the joint. M. Ruyer says that in his patient, on the thirtieth day, consolidation was perfect, and all the movements restored; which however seems to me somewhat difficult to believe. Even when complicated with a wound, this fracture is not so grave as we should be led to suppose. One patient, a woman of fifty-six, died on the fifth day; another patient recovered, but with notable loss of the movements of the elbow; and Ivimy's case was still more successful, since the woman regained in great measure the motions of flexion and extension.

The double indication offered, whether in making reduction or in choosing our apparatus, is to bring together the separated condyles, and to correct any displacement from the upper fracture.

The forearm being flexed at a right angle, Desault surrounded the upper half of the forearm, the elbow, and the middle of the arm, with a roller, making several figure-of-8 turns around the condyles; he then placed one bent splint in front and another behind, and a solid splint on each side; the whole being confined by fresh turns of the bandage.

M. Ruyer uses simply Boyer's apparatus for fracture above the condyles. Sir A. Cooper has represented in his Atlas two lateral angular splints for these cases, like those of Henckel for the fracture just named.

Without doubt these appliances are sufficient when we have merely to bring the condyles together; or we may resort to that advised by Lonsdale, a pasteboard trough receiving the elbow and half of the arm and forearm. But if there exist a displacement such as was observed by M. Huguier, or analogous to those pointed out in fracture above the condyles, we must at once employ the same apparatus as in the latter case.

An essential point here is to guard against anchylosis. On the twenty-second day, Desault and M. Ruyer laid aside the splints and began making passive flexion and extension of the forearm; they left off even the bandage after the thirtieth day. The success attending this plan affords a strong reason for imitating it.

The existence of an external wound calls for some modification of the apparatus. We must still keep up the flexion; but we must at the same time leave the wound exposed, in order to dress it. This

we can do by notching the pasteboard splints, or by using a fenestrated immovable apparatus. In the case reported by Lonsdale, there were several wounds at the elbow; Mr. Mayo devised an apparatus comprising: (1) a wide splint applied to the posterior face of the arm; (2) another splint of the same width, intended to support the forearm and hand without encroaching on the elbow; (3) two small steel bars, reaching from one splint to the other on each side, curved a little outward so as not to press upon the joint; so that, the arm and forearm being fixed on their respective splints, the elbow was exposed on all sides. This apparatus is certainly very ingenious; and perhaps this would be a case in which to apply the iron-wire troughs, leaving a space at the elbow, so as to fulfil the same indication with less trouble. As to the treatment required for the wound itself, it has been spoken of in connection with compound fractures generally; and I shall recur to it in discussing comminuted fractures of the elbow.

§ II.—*Fractures of the External Condyle.*

These fractures, if I may judge from my own experience, are the most common of all those which affect the articulating extremity of the humerus, and perhaps the most common of all those of the elbow. They are met with chiefly in young subjects, and almost always from falls on the outer part of the elbow, this being close to the trunk.

Several varieties of them have been described. Sir A. Cooper has given a drawing of one which passes along the upper edge of the condyle in front, to run finally into the joint; and he calls it an instance of intra-capsular fracture. I would observe in this respect that if this fracture was seated within the capsule in front, it was necessarily outside of it posteriorly; Sir A. Cooper's name for it cannot therefore be considered suitable. Some modern authors also have spoken of a fracture which did not penetrate into the joint, and which only involved the little projection of the epicondyle; but hitherto no one has given an instance of it. I assert therefore that all fractures of the external condyle are partly intra and partly extra-articular; and I admit but two essential varieties, one in which the solution of continuity involves only the condyle, the other in which it extends to the middle of the trochlea.*

I have given in *Fig.* 46 an example of the first form. The fracture is of long standing; yet in spite of the deformity induced, we may get a correct idea of it from the drawing, by taking into account the narrowness of the detached portion; and in the specimen itself

* [The *condyle* being the surface for the head of the radius to play upon, while the *trochlea* is the inner and hour-glass-shaped portion which articulates with the ulna.]

we see that at the posterior surface the fracture passes along the edge of the sigmoid cavity, which is hardly encroached upon by it. In *Figs.* 42, 43, and 44, the fracture, which is very oblique, has gone through the middle of the trochlea, the outer portion of which forms part of the detached fragment.

Here then are at once two great varieties, according as the condyle is broken off alone, or carries with it part of the trochlea. This being well established, it must be added that these fractures, like all others, vary greatly according as the periosteum remains intact, is torn to any degree, or is widely ruptured in the whole extent of the fracture.

In the first case there is no displacement; swelling more or less marked occurs at the outer side of the elbow, there is pain on pressure, especially about an inch above the epicondyle, and pain when the forearm is flexed or extended; these are the only phenomena that would make us suspect fracture; and the only means of arriving at a positive diagnosis is by crepitation, which is best elicited by putting the hand and forearm through the motions of pronation and supination.

Slightly as the periosteum may be torn, two symptoms present themselves in addition to the above, namely: mobility and displacement. The mobility is easily detected, unless the swelling be too great, by putting two fingers, one in front and the other behind the outer fragment, and moving it in these two directions. The most common displacement is due to the muscles attached to the epicondyle, which draw forward the upper extremity of the outer fragment; sometimes there is also a backward movement of its lower extremity, which carries with it the head of the radius; lastly, I have sometimes detected a widening of four to six millimètres in the space comprised between the two tuberosities, showing that the outer fragment was pushed outward. As to the inclination forward of the upper extremity of the fragment, there is one point not without importance; sometimes this displacement is so marked as to persist even after consolidation; at other times it is so slight that it seems wholly to disappear when the forearm is flexed; but it is reproduced by making at the same time extension and pronation, a fact which affords valuable aid in the diagnosis, and a not less useful indication for the treatment. It may be also that the muscles attached to the epicondyle keep the forearm in a state of constant supination; Desault saw such a case.*

But when by the external violence all the tissues capable of holding the fragments together are ruptured, then the displacement becomes so considerable that the articulation itself takes part in it, and there is an actual luxation accompanying the fracture. This is what

* *Œuvres Posthumes; Mém. sur la fracture de l'extrémité inférieure de l'humérus*, etc., § vi.

had occurred in the specimen represented in *Figs.* 42, 43 and 44. *Fig.* 46 shows a luxation of another kind, independent of the fracture, although due to the same cause; but I merely allude here to these various complications, to which I shall again refer in treating of luxations.

Is it possible for us to ascertain, in the living subject, whether the fracture is limited to the condyle or extends to the trochlea? When the displacement is considerable, and especially when it involves an actual luxation, it is easy to follow the direction of the fragment, and to perceive that the joint is compromised; otherwise we can only form conjectures; and even for this the swelling must not be so great as to prevent examination.

The prognosis varies in different cases. Sir A. Cooper has asserted that oblique fractures, situated in great part outside of the capsule, will at length consolidate; while intra-capsular cases remain obstinately ununited. I have already said that this distinction was inadmissible; and the following are the results of my experience in regard to this.

All such fractures without displacement unite readily, as far as we can judge from examination during life; and M. Nélaton has told me that he had in his possession a specimen in which consolidation was perfect. When the displacement is somewhat marked, and especially when the fragments are separated laterally, union may still occur, but requires a much longer time. Lastly, when the fragments are entirely disjoined, sometimes they remain separate, or at most union takes place by fibrous tissue (*Fig.* 46); or they may work upon one another, wearing one another away, becoming eburnated, and remaining connected only by a sort of external fibrous capsule, (*Fig.* 44.)

While the fragments are worn away at their surfaces, there is a very curious phenomenon occurring; namely hypertrophy, affecting the adjacent portions either of the fragments themselves or of some contiguous bones. The inner portion of the trochlea, (*Figs.* 42, 43, 44,) the articular surface of the condyle and those of the ulna, and the head of the radius, have especially undergone an exaggerated development; and *Fig.* 46 represents the same thing in a less marked degree. Finally, in both specimens we observe small rounded bits of bone, such as we shall find in much greater number in cases of crushing of the elbow; are these modified splinters? This seems to me most probable; but hitherto it has been only in fractures of the elbow that I have met with anything similar.

The treatment, when there is no displacement, consists merely in keeping the elbow semiflexed and immovable for twenty-five or thirty days, making some passive motion after the twentieth day, to prevent trouble from articular stiffening. When the condyle is broken off and drawn forward, the fractured surfaces should be first brought

in contact, and then the fragment put in a better position. Desault used in such cases the same apparatus as for fracture of both condyles; Sir A. Cooper applied merely a roller round the elbow, and a curved splint or pasteboard trough to support the elbow and forearm; or sometimes two lateral splints. For my own part, in a case of slight displacement in a boy nine years old, I applied a starched bandage, putting a graduated compress in front of the elbow, to push backward the upper end of the fragment, which tended to start forward; and the union was easy and perfect. If the projection forward were more obstinate, I should not hesitate to resort to the apparatus which I have recommended for fracture above the condyles.

For the rest, if the union is fibrous merely, the joint is not in much danger provided the fragments are not too widely separated. I saw in consultation with M. Amussat a child of twelve years, who for nearly two months had had a fracture of the external condyle, and as yet no consolidation. The space between the two tuberosities was increased by six or seven millimètres; the upper end of the fragment projected forward, its lower part about two millimètres backward; motion was much impeded, and there was still pain in the elbow; we thought that the joint would never wholly recover its mobility. However, by means of poultices to relieve the pain, and carefully directed exercise, the movement gradually increased; and when I again saw the child, nearly two years afterwards, flexion, pronation and supination were complete; extension was lost only to the amount of a few degrees, and there was every promise of its full restoration; the only remaining annoyances from the fracture were the persistent deformity of the elbow, a slight displacement of the head of the radius backward during extreme extension, and lastly flying pains about the elbow upon any change of weather.

This fracture may, like the preceding, be complicated with a wound, and calls for like treatment. Desault mentions a case of the kind, which resulted favorably.

Finally, the same violence which produces the fracture may sometimes cause also a luxation to either side; but this will be treated of elsewhere.

§ III.—*Fractures of the Trochlea, or Internal Condyle.*

Desault was the first to mention this fracture. After him Sir Charles Bell, in enumerating the fractures of the humerus near the elbow, speaks of those of the trochlea, and not of those of the external condyle, as though the former alone were exposed to separation from the rest of the bone. Sir A. Cooper says that this fracture is frequent, especially in children, although he has seen it also in

persons more advanced in life. In spite of this triple authority, I regard the lesion as extremely rare. For my own part I have never seen it; neither Desault nor Sir C. Bell relates instances of it; in the only case cited by Sir A. Cooper, there was at the same time fracture of the condyle and fracture of the olecranon, which would amount to a comminuted fracture of the elbow; nor could I present, as a simple fracture of the trochlea, (although this constitutes certainly a part of the lesion,) the formidable injury displayed in *Fig.* 45.

[In May, 1856, I saw a washerwoman, aged about 50, who had the inner condyle separated in consequence of great muscular exertion in lifting a heavy tub. The injury had taken place some two months before; there was much effusion into the cavity of the joint, and the heads of the radius and ulna were wide apart, but some use of the arm remained. The nature of the lesion was quite clear, and her account a plain and straightforward one. I was unable to follow the case up.]

M. Guéneau de Mussy has presented to the *Société Anatomique* a humerus in which may be seen a fracture of the internal condyle, of ancient date; the sigmoid cavity is divided into two portions by an osseous ridge, not occupying its entire depth.* Here is established at once the existence of such a fracture by itself, and the possibility of its consolidation. Had there been in this case any displacement originally? Our information on this point is deficient; we can only presume that, like that of the outer condyle, this fracture may exist without notable displacement.

When the fragments are forcibly separated by the external violence, the injury, according to Sir A. Cooper, presents peculiar phenomena. The detached portion is carried backward, drawing with it the ulna, with which it is articulated; so that the projection backward of the olecranon on the one hand, and the projection forward of the broken part of the humerus on the other, combine to simulate luxation backward of the ulna. But these deceptive appearances are only present when the arm is extended; when we bring it into flexion, the ulna resumes its normal position. So also the forearm, which in extension inclines inward with the hand, is restored to its usual direction when it is flexed; and lastly, if any doubt remains, we have only to grasp both condyles with one hand, while with the other we put the forearm through the motion of flexion and extension, to perceive a crepitus plainly referable to the inner condyle.

Should not this description of Sir A. Cooper's, and his remark as to the difficulty of diagnosis between the fracture in question and luxation, go to clear up the true character of some cases communicated in 1828 to the *Académie de Médecine?* A woman aged 45

* *Bulletins de la Société Anatomique,* 1837, p. 98.

had fallen upon her elbow; M. Caffort immediately diagnosed a luxation, and accomplished reduction with a facility which surprised him. Afterwards, passing his fingers along the borders of the joint, he perceived that the inner condyle of the humerus was very movable; and a distinct crepitus added to this left no doubt as to the existence of a fracture. M. Caffort asked himself whether the fracture had preceded the luxation, or the luxation the fracture, and inclined to the former idea. The question was not discussed by the Academy; M. Hervez de Chégoin said he had seen two analogous cases, but spoke only of their treatment.* It would seem to me extremely probable that there was nothing but a fracture simulating luxation.

Sir A. Cooper had at first recommmended in these cases the same treatment as for fracture above the condyles. But subsequently he contented himself with advising merely a roller around the elbow to keep the fragments in contact, the forearm being also flexed and supported by a sling. M. Caffort likewise applied merely a bandage; and M. Hervez de Chégoin also said that splints were useless, provided the forearm was kept flexed, since then the muscles attached to the epitrochlea were relaxed.

I think that all that was said concerning the treatment of fractures of the external condyle is perfectly applicable to this case also, and therefore refer the reader to the preceding section.

§ IV.—*Fractures of the Olecranon.*

This injury, somewhat more common than the foregoing, is nevertheless very rare, since during eleven years it occurred only nine times at the Hôtel-Dieu. Hoin did not see it once during thirty years of service in the hospital at Dijon, and his private practice afforded him but two instances of it. Camper likewise had met with it in but two instances in the living body. [During the last five years, eleven cases have been treated at the Pennsylvania Hospital, and one has occurred to me in Dispensary practice.] This rarity may explain why, after being mentioned by Hippocrates, Celsus, and Galen, fracture of the olecranon suddenly fell into com-

* *Revue Médicale*, 1828, tome iv. p. 367. I should mention that in the *Archives Gén. de Médecine*, tome xviii, p. 450, a somewhat different statement is given. Thus the patient is said to have been not a woman, but a man; M. Caffort is said to have added to his bandage two lateral splints of pasteboard, notched at their lower part to receive the condyles; and lastly Larrey, before M. Hervez de Chégoin, is said to have declared that the splints were of no use, and that he himself had successfully treated an exactly similar case by a simple bandage and position. The *Archives* state the term required for consolidation, in both cases, to have been forty days. Compare also the *Journal Gén. de Médecine*, tome cv, p. 273.

plete oblivion, not to reappear until the middle of the eighteenth century, in Duverney's treatise. Since then it has been the subject of some interesting researches.*

Men would seem more liable to it than women. I have collected twenty-nine cases from other authors, and six more from my own practice; of these thirty-five cases, only thirteen were women; and so also of the nine patients at the Hôtel-Dieu, there were six men and three women. It affects all ages nearly alike; of the nine patients at the Hôtel-Dieu, three were between eleven and fifteen years old, and two seventy-three and seventy-four; the remainder were of various intermediate ages. The cases I have collected have given me nearly the same result.

The most common cause is a fall on the elbow; this was given in twenty-seven of my thirty-five cases. Three times only the olecranon was broken by a blow with a stick or by the kick of a horse; and it is doubtless on account of the small surface presented by it that it so generally escapes direct violence. [In all the Pennsylvania Hospital cases direct violence is recorded as the cause. My own case was that of a very old woman, who in ascending a stairway came down on her elbow; she was very heavy, and there was a pebble lying on the step, upon which she struck.] Lastly, in five cases the fracture was ascribed to muscular action; but instances of this kind need to be very carefully inquired into.

The first is given by Bottentuit. A young man, trying to ward off a thrust while fencing, contracted his muscles so powerfully that he had the olecranon fractured.† This would seem to leave no doubt; but I find in the thesis of Capiomont an account of a similar fracture, also in a young man; Bottentuit, being consulted, attributed it to muscular action; and as he declares quite plainly that he saw but one case of this kind, it is fair to presume that the two accounts refer to one and the same case. Now Capiomont tells us that Deleurye, who came in after Bottentuit, asserted that the fracture could not have been caused by anything but a fall; hence the case must remain at least doubtful.

Capiomont gives also an account of a drunken horseman, who in beating his horse was thrown, and had his olecranon fractured, although he did not strike his arm in his fall. This fact of the fall leaves much doubt in my mind, especially as the story was derived from a drunken man. A third instance, reported by the same writer, may be considered as conclusive. A gunner, while working

* See Camper, *Diss. de fract. patellæ et olecrani*, Hagæ Com., 1789; Haighton, in *Duncan's Med. Comment.*, vol. ix, p. 382; Desault, *Journal de Chirurgie* and *Œuvres Posthumes;* Capiomont, *Thèse inaug.*, Paris, an xi, No. 19; and Thierry, *Thèse inaug.*, Paris, an xiii, No. 349.

† *Journal Général de Médecine*, tome xxiv, p. 377.

at a capstan, was left alone for some moments, and making a violent effort with his right arm, heard a crack, and instantly lost all power in the limb; the olecranon was ruptured. Richerand saw a similar result from an effort to throw a ball to a very great distance, and M. Blandin, from the motion of extending the arm in diving.* Lastly, I have myself had occasion to examine a man thirty years old, who, in playing with a comrade, his arm being stretched out, had his wrist suddenly struck so as to forcibly flex the forearm in spite of the resistance of the triceps; he felt at the time a pain like the prick of a needle, but did not give up work for several days; afterwards, flexion becoming more and more painful, he consulted M. Veyne and M. Robert, who made out a detachment of the apex of the olecranon.

As far as we can judge from so small a number of cases, it would seem that for the occurrence of these fractures there must be a certain degree of flexion of the forearm, this latter being then subjected to a force tending to flex it still further, which is resisted by the triceps. It is thus that the olecranon is broken in certain imprudent attempts at the reduction of old luxations of the elbow; I shall speak of this again at the proper time and place.

These fractures present several varieties, according to their seat. Desault was the first to distinguish two species, those of the summit and those of the base;† to which Boyer added a third, those of the middle portion. The base, referred to by Desault, was doubtless the same part which was called by Boyer the middle; but however this may be, I have made out really three varieties, corresponding very well with Boyer's division.

Fractures of the apex are the rarest of all; I can quote but two instances. They consist in a tearing off of the cortical layer which receives the insertion of the triceps, and in both those cases were the result of muscular action. This was what had occurred in the patient whom I saw after MM. Veyne and Robert; in the cannonier spoken of by Capiomont, although the description is deficient, we may presume that there was a rupture of the same kind, since several surgeons had called it a mere decollation of the tendon. Does the fracture in these cases communicate with the joint? I merely propose this question, not having the positive facts necessary for its solution.

Fractures of the middle portion are the most common of all; they divide the process just where its articular cartilage ends, where

* *Gazette des Hôpitaux*, 1845, p. 327.

† M. Littre has found this distinction made by Hippocrates, but by adding to the text a sentence of Galen's Commentary, preserved by Oribasius. I am afraid this interpolation is somewhat over-bold; and the expression used by Oribasius himself is very obscure, and susceptible of more than one interpretation.

the sigmoid cavity diminishes in size; their direction is nearly horizontal. These are, according to Desault, fractures of the base, and according to Cooper, fractures of the middle; they are said by both to be transverse; but on close examination it is extremely rare not to detect even during life a certain degree of obliquity from one side to the other, as in *Fig.* 47; and in the same specimen there was besides a marked obliquity from above downward, and from behind forward, (*Fig.* 49.)

Lastly, what we may call, if we choose, fractures of the base, are such as, running very obliquely from above downward and from before backward, commence within the articulation at the same level as the preceding, but descend backward so as to detach from the ulna the entire posterior and triangular face of the olecranon. I have twice seen this lesion in the living subject; and in one remarkable instance the fracture gave rise to luxation forward of the forearm.

Besides these principal varieties, the fracture may also be simple, or attended with some splintering, or even present the phenomena of actual crushing; finally, it is sometimes complicated with an external wound.

The phenomena of this injury are, in the first place pain, sudden loss of the power of flexing and extending the arm, contusion when the cause has been external violence, and almost always a greater or less degree of swelling. The examination being carried further, the elbow is found deformed; the olecranon more or less drawn up behind the humerus, and therefore out of line with the posterior edge of the ulna, and making a much smaller prominence posteriorly. Between the two fragments is an interspace, rarely perceptible to the eye, but into which the finger may be readily pressed; and if the two forefingers be applied, one on each side, fluctuation is perceived, sometimes doubtfully and sometimes very plainly. The separation increases when the forearm is flexed, diminishes when it is extended, and disappears if when the forearm is extended the upper fragment is brought down. By seizing this fragment between two fingers, we may move it to and fro from one side to the other; and by bringing it against the other, crepitation is quite readily elicited.

Let us dwell for a moment on some of these phenomena. The impossibility of flexion and extension of the arm does not arise from want of muscular power; the triceps is continued upon the ulna by the fibres of the anconeus, and the flexors have, on the other hand, a feebler opposition to encounter. But besides the pain, the swelling, and the effusion of blood within the joint, it must be observed that every contraction of the muscles, either in extending or in flexing the forearm, tends essentially to separate the fragments, and to stretch or even break the fibres which still unite them; thus one of Desault's patients said, on attempting to extend the arm, that he felt *something broken away from the elbow.* If the pain is trifling,

the movements are executed freely enough; I have even seen one case in which the man kept at his work as a tailor for two or three days after the accident; and afterwards, before union was complete, the motions were regained in proportion as the pain and swelling subsided.

The separation of the fragments has also a certain importance; it is sometimes hardly perceptible. Monteggia says he saw fractures of the olecranon from falls on the elbow, without any displacement whatever; and Sanson met with a case of the same kind. Sir A. Cooper explains this by the preservation of a special fibrous band extending obliquely from the coronoid process to the olecranon, and also of that part of the annular ligament of the radius which is fastened to the detached portion. Without denying the slight action of these fibrous fasciculi, it should not be forgotten that the olecranon is held laterally by the capsule of the joint, and especially covered posteriorly by a very thick periosteum, strengthened still more by a prolongation of the tendon of the triceps; if this fibrous envelope remains intact, there can be no displacement; and the separation doubtless arises at once from its rupture and from that of the capsular ligament.

As to the extent to which it may occur, Capiomont and Thierry cite cases in which it amounted to two fingers'-breadths; Sir A. Cooper saw it in one case as much as two inches. In this latter case, it should be mentioned, the capsule was torn through on each side of the olecranon; but what is particularly to be noted, he has represented this separation as increased by flexion of the forearm; whereas to judge of its actual degree the limb should be extended, as in the case of the patella. I doubt very much whether the separation would be thus found to be so considerable; and for my own part I have never seen it much over a single centimètre.

Finally, in reference to this separation, I must not omit to say that sometimes it does not show itself at the moment of the fracture, but comes on afterwards, as the effect of some sudden movement or of some fresh violence from without. Lonsdale quotes from Earle a case of fracture of the olecranon, in which the separation did not occur until the sixth day, and was then produced by a motion made by the patient in putting on his cravat.

These are, so to speak, the general symptoms; they are not the same in all the varieties. In fractures toward the summit, the detached fragment being very thin, the shape of the elbow is scarcely altered; so that in one case, as has been said, a mere rupture of the tendon was diagnosed. In those of the middle portion, the separation is more marked than in the others, and sometimes allows the finger, the forearm being flexed, to reach the trochlea; or, the forearm being extended, to pass into the sigmoid cavity. Fractures of the base have a special character owing to their obliquity; the upper

fragment is pointed, and stretches the integuments, while below it may be felt the ulna, bevelled at the expense of its posterior face. Perhaps an attentive examination would detect some preternatural mobility in the articulation of the ulna with the humerus; but having only seen these fractures a long time after their occurrence, I put forth this idea as a mere conjecture, to be tested.

As to splintered and crushed fractures, I have nothing particular to say here. In fractures complicated with a wound, there is sometimes a slight but persistent hemorrhage from the broken ends; I shall mention such a case in connection with comminuted fractures of the elbow.

The course of these fractures is ordinarily very favorable. The swelling disappears at about the tenth or fifteenth day, and union occurs quickly and firmly. According to Bichat, of eleven fractures of the olecranon treated in Desault's wards, four were united by the twenty-third day, three by the twenty-eighth, and four by the thirty-second.

But what is the nature of this union? In the living subject, when there remains some degree of separation, and the upper fragment is movable upon the other, it is manifestly fibrous; when the fragments are close together and immovable, we may presume that the callus is ossified. In order to clear up this point, Sir A. Cooper fractured the olecranon transversely in a dog and in several rabbits. Finding union always fibrous, he varied the experiment by dividing the process by a somewhat oblique vertical section, so that the two portions should remain in contact; and this time he obtained an osseous callus. Hence he concluded that want of contact was the only difficulty in the way of bony consolidation, which might be insured by approximating the fragments. I have represented, in the atlas to my volume on Luxations, such a fracture of the olecranon complicated with a dislocation of the elbow, but united again by bone.

It nevertheless appears that union is most commonly fibrous, either from some defect in the treatment, or from the form of the fracture. Desault and Sir A. Cooper each examined by dissection an old fracture of the olecranon, and in both cases the union was entirely fibrous. It may be alleged that the fragments had remained wide apart; but in the specimen I have had drawn, (*Fig.* 48,) the separation, especially on the outer side, is not very considerable; and yet there was no trace of ossific callus.

The fibrous tissue connecting the fragments is not even so firm as might be thought. Sir A. Cooper has remarked that it often, when of considerable length, presents one or more lacunæ. In *Fig.* 47 is seen such a lacuna, separating the fibrous callus into two lateral portions. But there is another fact of much greater importance; the fibrous tissue is not attached by the whole extent of the fractured surfaces; sometimes it is limited to their circumference, within which there is no attachment of any sort, as was very well marked in the

specimen represented in *Fig.* 49; Sir A. Cooper's drawing seems to show a similar arrangement. Sometimes the fragments, farther separated posteriorly than anteriorly, are only in contact by their anterior edge; this was found to be the case in M. Pasquier's patient, who was treated with the forearm at an angle of forty-five degrees, and who died three months after the receipt of the injury.*

Lastly, the uniting membrane may be entirely wanting; at least I have seen, in a trooper who had a very old fracture at the base of the olecranon, the upper fragment remaining quite immovable during flexion and extension of the arm, although it could be easily worked from side to side.

An important subject for study is the influence of fibrous union on the power of the limb. In 1785, Haighton reported the case of a boy of fifteen, who having had a fracture of the olecranon which was treated as a mere contusion, never completely regained the power of extending the arm. Sir A. Cooper asserts that the loss of force is in proportion to the length of the intermediate band; and that when this is very long, it diminishes the strength of the triceps, thus hindering extension. This idea has greatly prevailed among surgeons, leading them to keep the limb extended in order to prevent separation of the fragments.

There are however quite numerous facts showing this fear to have been at least exaggerated. Camper first gave an account of two transverse fractures, treated by means of the sling merely, united by fibrous tissue, and yet preserving to the injured limb an extension as complete as that of the sound one. Capiomont and Thierry have reported analogous cases; Boyer saw two instances in which the fibrous band was half an inch in length, but the forearm had recovered perfectly its motion and its strength. I have myself observed something still more remarkable; in the trooper before mentioned, in whom the fragment was unaffected by the movements of the ulna, extension was perfect, and the development of the limb was unimpaired.

Must we then believe that it is a matter of indifference that the olecranon is more or less elongated by intermediate fibrous tissue? Such is by no means my conclusion. As to the cases related by Camper and others, I doubt much whether the liberty of movement was so great as they would make us think, especially considering the new relations of the ulna, shown in the specimen which I have represented in three different aspects. (*Figs.* 47, 48 and 49.) We see, indeed, in *Fig.* 48, that the apex of the process is carried farther forward than naturally; in *Fig.* 49 that the fragments are farther apart behind than in front, which is explained by the preceding fact; in *Figs.* 47 and 48, that the separation is wider at the inner or ulnar

* *Gazette des Hôpitaux*, 1839, p. 109.

edge than at the outer, whence the apex of the olecranon is inclined over outward, coming into the same vertical line with the lesser sigmoid cavity. The inclination forward of the apex of the olecranon had also given rise at length to a flattening of that of the coronoid process; and all these little alterations of form and of relation would seem to me necessarily to involve some loss of freedom of motion.

The case in question was one of fracture of the middle portion; in oblique fractures of the base, direct observation has discovered to me phenomena much more unexpected. In a woman aged 39, who had for four years had an ununited oblique fracture, I noted particularly, that she could freely grasp any object when her arm was hanging down and her forearm flexed; but that if she stretched out the forearm, the fingers lost their power; and that if she at the same time raised the arm, her hand could no longer hold anything, relaxing involuntarily. But this was so singular, that I hesitated to attribute it to the mere fracture; another case was needed to assure me, and at the same time to put me in the way of plausibly explaining it.

This case I found in that of the trooper before mentioned, whose injury dated back twenty-five years. The limb as a whole was as well developed as the sound one; the patient could extend the forearm strongly, or grasp anything with his hand, and wielded a sword or a foil with quite uncommon power. But all this he could only do when the forearm was either supinated or in a middle position between this and pronation, and the arm lowered or only moderately raised. The hand when pronated was not so strong; when the arm was raised horizontally, it was much weakened; and any further elevation of it almost deprived him of the power of holding anything. Thus in the use of weapons, he had been obliged to abandon the back-sword; and he had likewise to avoid carefully any manœuvre in which his arm would be elevated.

I several times studied the conditions of this phenomenon, with the following results. When the extended forearm was raised to the level of the shoulder, the head of the radius passed forward about one-fifth of an inch, leaving the condyle of the humerus projecting just as far beyond it backward; the same thing occurred during pronation; but on the sound side there was nothing of the kind. Here was then a subluxation of the radius, produced in great measure doubtless by the action of the biceps; and probably the ulna underwent a similar displacement. But why was it peculiar to certain positions? This I cannot say; the phenomenon however seems to me to be confined to oblique fracture of the base of the process, for in an old fracture at the middle portion, which I lately had occasion to examine, the patient had not had anything like it.

There is therefore, at least in certain cases, marked inconvenience attending deficient union, or union by fibrous tissue, in fractures of

the olecranon. But before this can be felt, there is another still more urgent, which the surgeon should not lose sight of; and this is the stiffening of the elbow in whatever position we may put it; it is often very obstinate, sometimes amounting even to anchylosis; Trioen has given a drawing of an osseous fusion following a fracture of the olecranon, the preparation having been in the possession of Camper.

Finally, I would not omit another slight consequence which I have remarked after fracture of the summit of the process; for a long time afterwards the patient is unable to raise a somewhat heavy weight without having a sort of cramp in the arm; this however disappears in time.

The diagnosis and prognosis are deduced from all the facts hitherto given. The swelling around the elbow is sometimes so great as completely to mask the fracture, leading experienced surgeons to take it for a mere contusion. In such a case it would be most prudent to wait, and not form any opinion at once.

We must however guard against the opposite error, and not mistake a contusion for a fracture. A woman came to consult me after a fall on the elbow; the skin over the middle of the olecranon was abraded and as it were thinned, while above and below there was considerable swelling; so that the nail seemed at first to pass into an interspace between the fragments. But there was no crepitation, nor mobility of the upper fragment, nor increase of the separation in the position of extreme flexion; hence there was no fracture; but such a case would demand careful attention.

The treatment has been modified alternately in view of one or the other of these dangers, anchylosis and want of exact union. Two very different methods have thus arisen, according as we put the limb in the flexed or extended position; they may be called the *old* and the *new* methods.

Old Method; Semiflexion.—Hippocrates used in this, as in other fractures about the elbow, a simple bandage, keeping the forearm semiflexed. Celsus, following doubtless some surgeon of Alexandria, rejected even the bandage, adding that if we only remedy the pain, the limb will perform its functions as well as ever. Camper, in the eighteenth century, first revived the idea of Celsus, and recommended the employment of nothing but rest and a sling. Bottentuit, resuming the practice but not the knowledge of Hippocrates, applied a moderately tight bandage; and the numerous partisans of semiflexion have done little more than follow one or the other of these plans. The apparatus of Devilliers is the only one worthy of separate mention.

The case was one of fracture by direct violence, with separation of about one inch. After treating the swelling for five or six days by suitable fomentations, Devilliers applied over the olecranon a

long and thick compress, which he fixed by a few loose turns of a bandage. To the last of these circular turns, he attached two bands; these were fastened by their other ends at the wrist, keeping the forearm permanently flexed, or at least preventing its being extended without drawing down the bandage and compress, and therefore the olecranon also. Union, according to Capiomont, took place quickly and completely.

Modern Method; Extension.—This plan, first proposed by Duverney, is now universally adopted in England and Germany; and even in France and Italy, it probably has at present the majority in its favor. It comprises two secondary varieties, according as the extension is more or less complete; partial extension, such as was preferred by Duverney, Desault, Boyer and Monteggia, has remained in a great degree peculiar to the French school; while complete extension, adopted by Haighton, Sheldon, Sir A. Cooper, etc., forms the basis of the English system. Each, again, embraces numerous forms of apparatus.

Duverney's plan is certainly one of the simplest of all; he merely surrounded the elbow with a moderately tight figure-of-8 bandage, taking care not to press upon the olecranon, and placed the arm slightly flexed upon a pillow.

Desault commenced by surrounding the forearm, up to the elbow, with a roller; then grasping the olecranon in his fingers, he drew it down toward the other portion of the ulna, with the not unimportant precaution of having the integuments drawn upward by an assistant, lest, in their relaxed state from the extended position of the limb, they should be caught between the fragments. Coaptation being thus made, the surgeon substituted for the finger holding the olecranon a turn of the figure-of-8, continuing this figure until the elbow was entirely covered, and then carrying the roller on up the arm. He then put a long and strong splint in front of the arm, fastened it there by a bandage, and placed the limb on a cushion so as to make it lie evenly. The great point was that the splint had a slight angle opposite the bend of the elbow; according to Bichat, this should be so marked as to keep the forearm between extension and moderate flexion.

Boyer used no splint. He however adopted the bandage of Desault, with two modifications; first, he commenced the roller upon the hand, and secondly, before surrounding the olecranon with it he covered that process with a long compress, the two ends of which came forward and crossed one another on the forearm.

These bandages are apt to become relaxed, and besides that they do not hold the olecranon very firmly. M. Velpeau obviates the former difficulty by using a dextrinated bandage a good deal like that of Boyer, supported sometimes by long pasteboard splints. As for confining the fragment, Wardenburg tried a circular bandage placed

above it, drawn down by two bands going to be attached at the hand. Böttcher substituted for this a strap and buckle, and for the two bands two other straps firmly attached above to the first, passing downward to go between the thumb and forefinger and fastened together by a buckle; their tightness could of course be regulated at will. Feiler used a bracelet above the elbow, with three buckles; another buckle, attached to this just over the olecranon, received a strap fixed below to the back of a glove.*

It may easily be seen that these straps and buckles bring the limb into nearly complete extension; let us now run over those forms of apparatus in which this is assumed as the leading indication.

Camper, who introduced the idea in 1755, but renounced it almost immediately, employed two splints; Haighton used a hollow pasteboard one; but it was soon perceived that besides a proper position, some special traction upon the olecranon was necessary.

Dupuytren put an ordinary splint in front of the elbow, and acted on the fragment by means of a bandage like that for transverse wounds; a very doubtful plan, and one already abandoned by Desault himself.

Sir A. Cooper placed a wide tape or piece of bandage longitudinally at each side of the fragment. He then applied over these a wet roller circularly above the elbow, and another at the lower part of the forearm, and brought together the ends of each tape, so that by drawing them tight and tying them he approximated the two circular bands, the upper of which brought down with it the olecranon. A well-padded splint, placed in front, completed the apparatus, which was to be frequently wetted with spirits and water.

Alcock advised the use of a much simpler means, namely, a long strip of diachylon or lead-plaster, the middle of which being applied over the upper edge of the olecranon, its two ends were brought forward and crossed on the anterior face of the forearm.†

Amesbury, making use of Sir A. Cooper's idea, replaced the wet bandages by well-padded leather cushions, fixed, one above the olecranon and the other on the forearm, by three straps passing around the anterior splint also; these cushions were brought toward one another by two longitudinal straps passing on each side of the olecranon.

M. Mayor has endeavored to make with handkerchiefs an apparatus like that of Böttcher, adding a hollow splint at the bend of the arm, to hinder flexion. He ties around the arm above the olecranon a handkerchief folded cravatwise; this is drawn downward by a second, which is fixed by its middle between the thumb and forefinger, and the two ends of which, crossing one another at the back of the wrist, run up toward the elbow to be suitably attached to the one first mentioned.

* See Richter's work, and especially his Atlas.

† *London Medical Repository*, 1824, vol. i, p. 496.

There are two inconveniences about all these plans, and in fact about the entire method. The first consists in the trouble of keeping the limb pendent and encumbered with the apparatus; the second is the impossibility of making passive motion of the joint without stripping it. Most surgeons who advocate this method keep their patients in bed until consolidation is so far advanced as to allow of the elbow being moved. M. Baudens, having to treat the Duc de Nemours for a fracture of this kind, sought to avoid both these inconveniences. I shall pass over the apparatus itself, which was almost exactly like that of Dupuytren; but in order to enable his patient to go about, M. Baudens had constructed a hollow tin splint, well-wadded, and fastened at the axilla by two straps going over and crossing one another upon the opposite shoulder; to this splint, at about its middle, was jointed a wooden support eighteen inches long, which being received into a socket like that of a standard-bearer, fixed at the hip, maintained the splint and the arm in a horizontal position.*

Such are the principal means recommended for fracture of the olecranon. If now we seek to estimate the value of each, it is evident in the first place that the old method has in its favor its simplicity, its facility of application, and, so to speak, its agreeableness; since all that is necessary is a sling, and the patient can go about from the very first day, using his arm as soon as the pain abates. If it be true that there is no fear as to the functions of the arm after this treatment, it is incomprehensible that so many surgeons have adopted the opposite plan; and even taking into account the actual consequences which I have clearly made out, I do not know that in a fracture of this kind in the left arm I should attach much importance to extension. But in the right arm it is another affair; it is very important that the limb should lose nothing, and to say the least of it, the modern plan is the one which affords us most security in this respect.

This being granted, the first question is how far we should carry the extension. Desault feared that if the arm were completely extended, the fragments would be in contact behind, but separated in front; or that if they did not come together, one of them would sink into the sigmoid cavity, thus passing forward out of the way, and leaving the other behind; so that in either case there would be irregular union, and some impairment of motion. All this is so hypothetical that Boyer has made no account of it. According to him, the connection is always fibrous, and therefore the advantage of having a less separation of the fragments does not counterbalance the fatigue induced by complete extension, or the danger of articular stiffening from a position so unfavorable to the functions of the limb.

In the first place, Boyer's denial of osseous consolidation is set

* *Bulletin de l'Acad. de Médecine*, tome ii, p. 575.

aside by facts; and the argument as to stiffening of the joints has likewise but an equivocal value. Doubtless complete extension endangers stiffening of the elbow; Thierry cites a case in which, after six months of painful manipulations, there still remained great rigidity. I have myself seen an analogous case. A grenadier aged 26, had fallen upon his elbow; the ecchymosis and swelling gave the idea of a mere contusion, and it was not until the sixteenth day that the fracture was recognised. Complete extension by means of an anterior splint was then resorted to; but union did not progress favorably, and after fifty days in the hospital, although he could extend the forearm well, its flexion was very limited, and caused separation of the fragments; the olecranon seemed anchylosed in the sigmoid cavity.

But are the plans of Desault and Boyer better fitted to prevent these consequences? Thierry reports two cases which are quite conclusive on this point. A woman with fracture of the left olecranon was treated with Boyer's apparatus; coaptation was exact, and no trace of the fracture remained; but the articulations of the elbow, wrist and fingers were so stiff that their movements were not regained until a year had elapsed, and then only at the price of excessive pain and great perseverance. Another woman, treated in the same way, had likewise marked rigidity of the joint; Thierry wished gradually to overcome it; but the patient had not sufficient courage to submit, and the elbow finally became completely anchylosed.

Thus, in these two cases, partial extension gave less favorable results than complete. But even semiflexion does not obviate the danger of obstinate rigidity, as is shown in a remarkable instance given by Sir A. Cooper; and I have proved, in discussing the general subject of anchylosis, that there is no position whatever which leads to this result unless when combined with too prolonged restraint. The true conclusion from all this is, that we should guard against anchylosis, without ceasing to aim at consolidation; and not forget either in our anxiety about the other.

Complete extension approximates the fragments to the greatest possible degree, and should therefore, generally speaking, be preferred. As to the choice of apparatus, we should first insure absolute immobility by applying a splint, either plain or hollow, in front of the arm; after this an adhesive strip, as used by Alcock, either by itself or with the addition of a thick compress above the olecranon, is assuredly the simplest means of acting efficiently upon the upper fragment.

[The above plan has been followed successfully in the Pennsylvania Hospital, in the few cases of the injury in question which have been treated there. The adhesive strips are, however, applied first, and do not quite surround the member; and the roller is made to extend from the fingers nearly up to the shoulder. The length of

the splint has a good deal to do with its efficiency in restraining flexion.]

If we would attain still greater security, at the expense of greater complication, Amesbury's apparatus seems to me to best fulfil all the conditions.

Whatever apparatus we may prefer, there are some important precautions to be observed in its application. In the first place, we should have the skin drawn upward, according to Desault's precept, to prevent its becoming engaged between the fragments. Next we should be careful to bring down the upper piece evenly, so that it may not remain inclined to one side or the other, as in the specimen I have had represented; and if this inclination is the effect of contraction of the triceps, we must seek to correct it. Lastly, the surgeon should bear in mind that in robust persons who follow laborious occupations, the forearm is no longer in a direct line with the arm, but generally makes a slight angle with it; in such a case the shape of the anterior splint is to be accommodated to the form of the limb, and the bend of the elbow so padded as to prevent any distortion.

Another question of no less importance arises, as to the period when it is proper to put on the apparatus. Desault applied it at once, regardless of the swelling; Boyer waited for this to subside, and if it remained until the twentieth day, considered the organisation of the callus sufficiently advanced to render any apparatus useless. It has been seen, indeed, in the case of the grenadier just cited, that the apparatus, applied on the sixteenth day, did not diminish the length already acquired by the fibrous band.

The rule should be the same in this as in every other fracture. Every enveloping and compressing apparatus is likely to do harm while the swelling and inflammation persist; but the position should be carefully attended to, if we would not run the risk of irremediable separation of the fragments.

Finally, when and how is motion to be impressed upon the joint? Duverney only waited a few days; Bottentuit postponed it for two weeks; Sir A. Cooper thought a month should be allowed to elapse, lest the olecranon should be forced away from the rest of the bone, and the fibrous tissue be stretched and weakened. I think that the surgeon should be governed by the degree of the foregoing inflammation, which would influence the danger of stiffening. But if it be thought proper to use such motion before the end of a month, it is important for us to observe great gentleness and caution. Bottentuit fixed the olecranon with his left hand, while with his right he put the forearm gently through limited movements, which he repeated and extended every two days. There would be still less risk if the surgeon, grasping the forearm with both hands, should bear upon the olecranon with both thumbs, so as to act at once on both fragments.

M. Baudens judged it necessary, at the twenty-eighth day, to apply in his case a hollow splint with a hinge at the middle, the angle being regulated by a screw, so as to make the movements still more exact; and in spite of the judicious use of frictions, douches, and exercise, the cure was not completed for two months. [I may say here that it is the opinion of many American surgeons that in all fractures near joints, by the exercise of extreme care in grasping and confining the fragments, passive motion may be made with safety at an early period; perhaps in most cases by the tenth or fifteenth day.]

It is mainly by perseverance in exercising the elbow that we can hope to remedy stiffening of the joint; but we have to treat cases also in which the functions of the limb are impaired by the degree of separation of the fragments. Sheldon has given the more than bold advice to lay the bone bare, and to rasp the fractured surfaces so as to again attempt their approximation.* Wright tried in one case compression by means of a roller, pasteboard splints, and two pasteboard troughs, as firmly applied as the patient could bear; this apparatus was kept in place for two months, at the end of which time, it is stated, the mobility of the fragment had entirely disappeared. Finally, it is said that Dieffenbach, in an analogous case, began by rubbing the two fragments together so as to cause severe pain, and then divided the tendon of the triceps, and kept the forearm semiflexed by means of a starched bandage. Every fifteen days the rubbing was repeated, and the apparatus renewed; and at the end of three months the fracture was found to be united.† I would not employ either of these plans, which would seem to me better calculated to induce stiffening of the elbow than union of the fracture; and I notice that in these two cases we are left uninformed as to the condition of the elbow after the treatment, or the degree of benefit derived by the patient. The only rational course here again would be to persevere in exercising the joint, in order to increase the power of those portions of the triceps muscle which are inserted into the lower fragment.

I shall say but a few words concerning this fracture when complicated with an external wound. If we are called immediately, we should try to obtain union by the first intention, and then to act as in a case of simple fracture. Sir A. Cooper has twice seen this plan successfully followed. But if suppuration occurs within the joint, the danger of anchylosis is too imminent for us to leave the arm in

* *An Essay on the Fracture of the Patella or Knee pan: containing a new and efficacious method of treating that accident. With observations on the fracture of the olecranon.* By John Sheldon; London, 1789. I have been unable to procure this work, and merely quote from Richter. [This work is in the library of the Pennsylvania Hospital; the author says he has never attempted the operation, but thinks it might answer in some cases.]

† Wright, *Journal des Progrès*, tome xv, p. 103; Dieffenbach, *Gazette Médicale*, 1841, p. 740.

the extended position; we must, as in the case of other complicated fractures of the elbow, keep it semiflexed and at perfect rest.

§ V.—*Of Comminuted Fractures of the Elbow.*

It happens sometimes, as the result of a severe fall, of the passage of a carriage-wheel, or of the application of any crushing force, that the elbow is comminuted, most generally with an external wound. We then meet with various combinations of the different fractures already mentioned, but with a great many splinters; and all the bony constituents of the joint may be involved.

Fig. 45 presents the most curious example within my knowledge, of a comminuted fracture of the elbow brought to a comparatively very favorable issue. The subject was a woman aged 57 years, who twenty-seven years before had had her elbow crushed by a heavy gate being suddenly shut upon her. Enormous swelling ensued, which she treated by emollient poultices; at the end of three months she began to regain some motion, and gradually, in spite of the deformity which may be imagined, she acquired the power of flexing the arm to some extent, of carrying the hand to the head, and of pronation and supination.

On examination a little while before her death, the arm was measured from the acromion process to the tip of the finger, and found shortened by one and one-third inch; the olecranon was drawn up about an inch on the posterior surface of the humerus, and a little inward also; on the outside there was felt a hollow above the tubercle of the radius; and as in rotation there was perceived crepitation at this point, there was diagnosed a luxation of the ulna backward and a little inward, together with an ununited fracture of the upper extremity of the radius.* The preparation, which I have had drawn with the bones separated, shows also other lesions.

There was in the first place an oblique fracture of the trochlea, and crushing of the detached piece, several bits of which are seen like foreign bodies in the joint. The olecranon and coronoid processes, and the intermediate bone, were likewise crushed, and reunited into a wide flat surface continuous with the anterior face of the ulna, only crossed below and in front by a sort of ridge adherent by its inner end. What is quite curious, the upper and inner angle of this wide surface seemed formed by the epitrochlea, fused with the olecranon; the muscles retained their attachments to it. Lastly, the head of the radius had been separated from its shaft, to which it was held merely by a slight fibrous band.

What was very remarkable in this case, and what especially accounts for its favorable termination, is that with such severe internal

* Callé, *Bulletin de la Société Anat.*, 1835, p. 133.

injury there was no division of the integuments. But as has already been stated, this happy condition is rare; generally there is at least one external wound.

Sir A. Cooper has made a curious observation in regard to this; it is, that these compound fractures generally affect the inner condyle, and he cites in fact two cases in which this portion of the bone, being broken, protruded through the integuments. In the only example of comminuted fracture of the elbow which I have seen, the humerus was on the contrary intact, except that its articular cartilage was stripped off; the patient had fallen from a second story upon the elbow, and the wound answered merely to a transverse fracture of the olecranon, leading me to think that this process alone was involved. The patient dying at the fifty-eighth day, the autopsy revealed a comminuted fracture of the coronoid process of the ulna, as well as of the head and neck of the radius.

This case shows also how widely we may err in our diagnosis, mistaking a very extensive injury for a single limited fracture. It presented to me also a phenomenon which it may be well to mention. After having assuaged the inflammation and lessened very much the suppuration, I perceived protruding from the wound a sort of blackish fungus, which bled at the slightest touch. I was at first uncertain as to its nature, but at last ascertained that it was simply an unorganised clot. It came away, and was followed successively by several others which in their turn also fell off, each time with a slight hemorrhage. At the autopsy I found the joint full of black clots, extending downward for an inch around the crushed bones. No vessel of any size had been ruptured, but this incessant hemorrhage seemed to have been an oozing from the spongy tissue of the bone.

On the whole, compound comminuted fracture is always a very grave lesion, and often requires amputation, either primarily or secondarily; but we should avoid resorting to this prematurely. In one case, in which the joint was so opened that the finger could be passed through and feel the artery pulsating in front, Sir A. Cooper proposed amputation; but the patient refused to submit to it, and his arm was actually saved. Kirkbride has also related two instances of recovery from severe compound fractures of this kind.*

We must in these, as in all other compound fractures, remove any splinters which are loose, or but slightly adherent; seek to allay inflammation, and if at all possible to obtain union of the wound by the first intention; if this cannot be done, free openings should be made for the escape of the pus. The most absolute rest is necessary; in order to which the forearm should be kept flexed at a right angle, by means of the same apparatus as in fractures of both condyles; but cicatrisation once completed, we should immediately begin passive motion of the joint.

* *Am. Journ. of the Med. Sciences*, Aug., 1834, p. 312.

CHAPTER XIII.

FRACTURES OF THE BONES OF THE FOREARM.

These fractures are certainly very common, since, even excluding those of the olecranon, they comprise more than an eighth of the whole number treated at the Hôtel-Dieu. Lonsdale goes so far as to say that they are the most frequent of all; an evident error, which may be explained by the mode of treatment of the different fractures at the Middlesex Hospital; those of the upper extremity being made out-door cases, and not limited as to number; while those of the lower extremity being received into the institution, the number of admissions is necessarily regulated by that of the beds. I shall recur to this question in connection with fractures of the lower extremity of the radius.

We shall study successively fractures of both bones, or *fractures of the forearm*, properly so called; fractures of the ulna; and fractures of the radius, which are subdivided into those of the shaft and those of the lower extremity of the bone. But it will not be uninteresting to cast a glance at their relative frequency and the predispositions affecting each.

Fractures of the radius alone are more common than those of the forearm, and these again are more common than those of the ulna.

If we inquire into the influence of age, we find fractures of the forearm and of the radius quite common in infancy, while they steadily increase in more advanced life; those of the ulna on the contrary hardly occur at all except in fully developed subjects; of twenty-nine cases, twenty-eight were above the age of twenty, and the remaining one was over ten.

As to sex, of fractures of the ulna four-fifths occur in men; twenty-three to six; of those of the forearm and radius, only three-fifths; sixty-seven to forty, and ninety-five to sixty-five. But as regards the last two, the proportion of the sexes varies curiously in the different ages.

In the forearm they are in equal number from two to fifteen years; from fifteen to twenty, there are eighteen men to one woman; from twenty to forty-five, the number of men just doubles that of the women; after forty-five, the women regain their equality, and even go a little beyond it, being twenty-two to nineteen.

In the radius, the number of male cases to female is ten to one in infancy; between fifteen and twenty it is fifteen to one. Thus up to twenty years of age this fracture is almost exclusively masculine. From twenty to forty-five, it affects women in pretty large numbers; twenty-two in a total of seventy two, or nearly the same proportion as in fractures of the forearm. But after forty-five, another change occurs, and the fracture displays a marked preference for the female sex; there being but twenty men to forty-one women.

The influence of the seasons is almost as varied. Fractures of the ulna are as frequent in summer as in winter; those of the forearm are more common in winter, while those of the radius abound more in summer. But these latter, in winter, affect women a little more frequently than men; while in summer the number of male cases more than doubles that of the females, being sixty to twenty-six.

§ I.—*Fractures of the Forearm.*

The causes of these fractures are almost always direct, such as a severe blow, a fall in which the forearm strikes against something, the passage of a carriage-wheel, etc. Sometimes the fracture is indirect, as from a fall on the hand; but this is quite rare. Lastly, I have had to treat one fracture occurring under circumstances which were quite exceptional. One of the insane patients at Bicêtre, thirty-eight years old, otherwise sound and robust, was digging in the fields, when in trying to lift a shovelful of earth he heard two distinct cracks in the right forearm, and was immediately disabled from work; the next day I made out a fracture of the radius about the middle, and one of the ulna about an inch lower down, with considerable displacement. This was therefore a fracture from muscular action; of which I have hitherto met with no other instance.

These fractures present some varieties, according to their seat and direction. In general they occur at about the middle of the forearm; more rarely in the lower third; those of the upper third are the most unusual of all. Sometimes the two bones are broken at the same, sometimes at different levels; and in the latter case I have always seen the radius broken higher up than the ulna. (See *Figs.* 51 and 52.)

I have elsewhere stated that partial fractures, in young patients, were more frequently met with in the forearm than in any other region; they are almost always the result of a fall on the palm or back of the hand. It would be needless to repeat what was given of their history. (See page 53 *et seq.*)

These fractures when complete present generally wide serrations, without marked obliquity; although they may be somewhat oblique.

They may also be comminuted, or perhaps divide each bone at two different points; thus Desault saw a forearm broken, by the passage of a cart-wheel, at its middle and lower portions; it presented six fragments, distinct one from the other.

The symptoms of these injuries are in the first place those of fracture generally: pain, loss of power, mobility, crepitation, etc.; but the displacement alone calls for special study.

Sometimes in children there is no appreciable displacement; and I have seen one such case also in an adult; but this is rare, and Boyer even asserts that displacement is always present.

These displacements are of several kinds. Sometimes both the lower fragments incline to the upper so as to make an angle salient anteriorly or posteriorly, when the forearm seems to be bent at the seat of injury. More commonly the inclination is in the other direction, the fragments of the radius approaching those of the ulna, and the interosseous space being narrowed or even obliterated. It is rare, when this occurs, for the fractured surfaces not to be more or less separated; and hence a displacement in the direction of the thickness, in virtue of which the fragments move upon one another in various directions. Displacement by rotation may also be produced by putting the hand into complete pronation or supination without first insuring coaptation; but especially does it almost always accompany overlapping, by a mechanism which will be mentioned directly. Lastly, overlapping occurs here, as elsewhere, under two conditions: either the fragments, being divided obliquely, are drawn upon by the muscles, or, in a nearly transverse serrated fracture, they have been completely disjoined; in this case, the overlapping, according to what I have seen, is more marked than in the former. I have dissected a recent fracture in which the shortening amounted to nearly two-thirds of an inch; and there is in the Musée Dupuytren a specimen in which it cannot be less than two and two-thirds inches.

These different displacements may be variously combined; *Figs.* 51 and 52 give a very accurate idea of them.

The fracture represented in *Fig.* 52 is at about the middle, and at the same level in both bones. As far as we can judge from the callus, it was oblique downward and backward in the radius, downward and outward in the ulna. Consequently, the lower fragment of the radius has passed up some millimètres in front of the other, the point of which is seen to project backward, and the lower fragment of the ulna has likewise passed up on the inner side of the upper. This upper fragment of the ulna is therefore in a manner interposed between the two lower fragments, keeping them apart, so that the interosseous space between them has lost nothing in width; while above this space has been greatly reduced, and in one point even obliterated, by the approximation of the upper fragments. There was,

however, no fusion of the two bones, and the motions of pronation and supination could still be executed, though to a very limited extent. Lastly, in the specimen, the two lower fragments formed with the two upper an angle salient backward, which could not be shown in the drawing.

Here then is slight overlapping in an oblique fracture; *Fig.* 52 displays greater displacement in a nearly transverse fracture, with other peculiarities quite worthy of notice.

The fracture in this case has occurred in the lower third of the radius, and in the lower fourth of the ulna. The inferior fragment of the ulna has passed up backward, that of the radius forward; which could only take place through marked rotary displacement, the lower part of the arm nearly approaching pronation, while the upper part still remained nearly supinated. From this rotation it follows that the inferior fragment of the radius, carried in front of the superior fragment of the ulna, is separated by it from the inferior fragment of the latter bone; so that below the interosseous space is almost entirely preserved, while higher up it has been considerably reduced by the approximation of the two upper fragments.

By what mechanism are the two lower fragments thus thrown one forward and the other backward? Probably from the external violence placing the forearm in semipronation, and then after causing the fracture giving the lower fragments a movement of pronation, so as to bring that of the radius forward and that of the ulna backward. I have had an opportunity of ascertaining, in a recent fracture of this kind, the essential cause of the fragments remaining in their new relations, which also prevents, in the majority of cases, the occurrence of any very considerable displacement; it is found in the overlapping of the two portions of the interosseous ligament, which serve to keep apart all the fragments; the upper portion of the ulna slipping in front of the lower portion of this ligament, and the upper portion of the radius behind it.

But sometimes the rotation takes place in the opposite direction, as if the lower portion of the forearm had been placed in supination by the fracturing cause; and then it is the lower portion of the ulna which comes forward, while that of the radius goes backward. Such was the case in my insane patient, whose fracture seemed to be the result of muscular action; when the subsidence of the swelling enabled me to ascertain the relations of the fragments, I found them in the first place deranged in the manner stated; but moreover, what is curious, the two upper fragments seemed interposed between the two lower ones, thus separating them by more than the normal distance. To give some idea of this, the width of the forearm, taken between the two bones above the fracture, was not quite two inches, while below the fracture it was about two and a half. Just such a displacement, except that the overlapping is much more considerable,

may be seen in the Musée Dupuytren, (No. 93;) it has been represented in the atlas of that museum, so that I cannot myself give a drawing of it.

It seems, then, in the first place, that when the overlapping involves both bones at once, the upper fragments always approach one another; and moreover, that according as the lower fragments have been twisted into pronation or supination, they maintain their natural degree of separation or undergo an increase of it.

I said, when the overlapping involves both bones, the radius may be fractured with overlapping by a fall on the hand, the force then exhausting itself in breaking the ulna, which presents little or no displacement. I have had such a fracture represented in *Fig.* 53; the radius is broken about two inches above the joint; its lower fragment is carried slightly backward, but very much inward, and the ulna is bent so as to meet it. Hence we find the articular surface of the radius drawn upward, and a very great deviation outward of the hand. The ulna projects very strongly above the carpal bones, and its styloid process, further removed from the pisiform bone than usual, is separated from it by a sesamoid bone developed in the substance of the ligament.

When there is little or no displacement, the course of the fracture is very simple, and union occurs in about thirty days. But when the displacement is considerable, or perhaps when the external violence has been very severe, we often see very great inflammatory swelling, and in no fracture is gangrene so likely to occur from the pressure of apparatus. Sometimes the mortification attacks the points directly compressed; sometimes phlyctenæ appear first between the fingers or on the hand. Bichat confesses that this accident happened quite often in Desault's practice. If immediately attended to, the gangrene may be limited to the points primarily affected; but more than once, in limbs too completely enveloped by bandages, it has pursued its insidious march until amputation was the only resource.

Aside from this danger, every fracture of the forearm with displacement is a lesion productive of serious consequences. Too often it involves loss of the movements of pronation and supination; I have seen several examples of this unpleasant result, which is especially to be apprehended when the bones are broken at the same level. It is not even necessary that the fragments should be in contact with one another; the collections of the *Faculté* [*de Médecine*] afford two instances of soldering together of the two bones at a distance, by bony prolongations traversing the interosseous space.* In more favorable cases the bones are not soldered together, but the motions of pronation and supination remain more or less limited; which may

* J. Cloquet, art. *Avant-bras* in the *Dict. de Méd.* en 30 vols.

be explained both by the narrowing of the interspace, and by the crossing of the fragments. Lastly, I have twice witnessed even more deplorable results; the motions of pronation and supination being lost, doubtless by union of each fragment with the opposite piece of the other bone, and the solidity of the forearm being destroyed by the non-adherence of the upper and lower fragments.

The prognosis should be based on these views, not however forgetting the influence of skilful or unskilful treatment. The diagnosis is established by crepitation, deformity, and shortening, and in any case whatever by preternatural mobility at the seat of fracture.

The treatment is very simple when there is little or no displacement; in fact no reduction is needful in such cases. So also when the fragments are only inclined toward one another, extension is entirely useless; the surgeon should correct any angle that they may form; when they are so approximated as to lessen the interosseous space, he should try to push them outward in the manner which will be stated directly. In other words, extension is unnecessary unless there is great lateral displacement, or overlapping.

In these latter cases, the forearm and fingers should be semiflexed; an assistant, grasping the arm near the elbow, should make counter-extension, while another takes hold of the wrist and makes extension. These two assistants are enough, if the surgeon is called a few hours after the accident; if not, we must employ more, making them pull upon handkerchiefs fastened around the elbow and wrist, and we must not shrink from using great force. Hippocrates complains that the surgeons of his time did not use enough; and we should err greatly in believing with Boyer that the reduction is always easy. The position of the limb is not a matter of indifference; we should pull first in the direction into which the fracture has thrown it; and when the broken ends are brought to the same level, or even drawn somewhat apart, we should bring the lower fragments into supination if they have been pronated, and *vice versâ*.

Having thus put the fragments end to end, we must think of restoring the interosseous space. In order to do this, we are directed to hold the forearm in a state of semipronation, and then, applying the thumbs on the dorsal face of the limb, to bear with the fingers of both hands on the palmar face, trying by suitable manipulations to push aside the muscles and thus remove the fragments of the radius from those of the ulna.

I doubt if any one has ever entirely succeeded by this method, which I have almost always seen to fail completely. When the forearm leaves the supine position, the radius tends to cross over the ulna, and the fingers cannot sufficiently penetrate the interosseous space. Supination is therefore to be preferred.

The same question comes up in regard to the application of the apparatus, and has been mooted ever since the earliest times. Hip-

pocrates states that the surgeons of his day kept the forearm in the supinated posture; he disapproves of this plan. His authority prevailed so completely, that in the sixteenth century A. Paré, after finding fault with semipronation, and proving the advantages of supination, changed his ground when he found that it was opposed to that taken by Hippocrates. I had thought myself the first, after Paré, to return to supination; but I have found that Lonsdale was before me, he having recommended it since 1832; and still more recently it has been stoutly defended by M. Bidart.*

The only reasons in favor of semipronation are, that it keeps all the muscles equally relaxed, and is most convenient for the patient; they have been amply sufficient to induce surgeons to prefer as a general rule a middle position for fractured limbs. But these general views should yield here, as elsewhere, before special indications. Now in the forearm, when the two bones approach one another so as to narrow the interosseous space, it is of essential importance to restore this space, if we would preserve the movements of pronation and supination, and the convenience of the patient should be sacrificed to his ultimate advantage. Lonsdale has added another argument; he thinks that the upper fragment of the radius often remains supinated, and that even in bringing the lower one into contact with it, if we keep the forearm in the middle position, we only perpetuate the rotary displacement of one of the fragments upon the other; which may explain why, after treatment on the usual plan, it is mainly supination that is impaired. This view does not seem to me based upon positive facts, and needs further proof. I would therefore limit the value of supination to those cases only in which the interosseous space is compromised; in all others, semipronation affords as many advantages and fewer inconveniences.

[If any one will take an articulated skeleton of the arm, and try these different positions of the forearm, it may easily be seen that it is only in semipronation, or when the thumb is turned directly upward, that the *radius and ulna are parallel.* With this idea, and not with that of relaxation of the muscles, or the comfort of the patient, this position is rigorously adopted in *all* fractures of the forearm in the Pennsylvania Hospital, and by very many surgeons in the United States; and the plan is so uniformly successful that it is only where some unusual complication is present that perfect use of the limb is not regained. It may perhaps be said that cases of deformity after fracture of both bones of the forearm are of very rare occurrence.]

The forms of apparatus proposed have also varied. From the time of Hippocrates down to the eighteenth century, surgeons used

* Lonsdale, *London Medical Gazette*, vol. ix, p. 910; Malgaigne, *Anat. Chirurgicale*, tome ii; and *Gazette des Hôpitaux*, 1839, p. 437; Bidart, *Journal de Chirurgie*, 1845, p. 199.

merely simple splints, without at all attempting to restore the interspace between the bones. J. L. Petit first conceived of putting two thick compresses, one in front and the other behind, so as to press the muscles in between the bones, and separate the fragments; unfortunately, he begun by the application of a roller, securing the compresses by a second, so that their action was entirely nullified.

This plan however embodied an idea which was taken up and improved upon by Pouteau. His apparatus consisted of two rolls of linen or tow, as long as the forearm, and at least an inch thick. These two rolls were placed directly upon the skin, fastened by a loose circular bandage, and then over each was laid a small board or wooden splint, a little wider than the forearm. The spaces between the edges of these splints were filled with linen or tow, and over all were applied circular turns of a bandage, much more tightly drawn than the former one.*

Desault, who would seem to have been unacquainted with Pouteau's work, employed a nearly similar apparatus, substituting graduated compresses for the rolls of linen or tow, and aiding the two first splints by two others, arranged along the outer and inner borders of the forearm. Boyer, rejecting these latter as useless, thus readopted exactly the means used by Pouteau, except that he retained the graduated compresses; but he insisted on these being thick enough to make the dorso-palmar diameter of the limb greater than the radio-cubital. Such is the apparatus which is still most generally employed in France, with the slight modification of dropping the first bandage, and applying the splints directly over the compresses.

It would be useless to describe all the modifications of this apparatus, differing from it only in the form and material of the splints, in the use of straps instead of bandages, or in the solidifying of these latter with starch or dextrine. The only two improvements sufficiently marked to merit attention are those of Amesbury, who sought to hold the two bones apart by means of convex splints, and of M. Nélaton, who substituted for the graduated compresses pieces of cork, in the following manner.

He had to treat a fracture of the forearm in which the radius presented a middle fragment which could hardly be retained in place. He commenced by applying a dextrinated bandage loosely to the hand and forearm; after which a long cork was laid over each interosseous space, opposite the middle fragment of the radius, and fixed there by several turns of a roller, pressing it in between the bones; when the apparatus became dry, the corks were removed, but left a longitudinal depression in front and behind sufficient to maintain accurate reduction. M. Nélaton remarks that in place of putting

* Pouteau, *Œuvres Posthumes*, tome ii, p. 261.

the corks above the dextrinated bandage, we might apply them to greater advantage directly upon the skin, covering them with a roller.

The first objection I have to bring against all these forms of apparatus is that they are applied in a position unfavorable to the end sought. I repeat, and I would beg all surgeons to prove it upon the skeleton, supination is indispensable to the complete separation of the fragments.

Most of them are open to a second objection, in regard to the length of the rolls or graduated compresses used. By making them as long as the forearm, we give them above and below two *points d'appui* upon the extremities of the bones, preventing them from sinking as they should into the interosseous space at the middle. A third inconvenience results from the want of parallelism of the two bones, the upper extremity of the radius being on a plane anterior to that of the ulna; so that the compresses, resting equally at all points, tend to press the upper fragment of the radius backward, and that of the ulna forward.

It would not suffice even to reduce them to the exact length of the interosseous space; for this space becomes very narrow above and below, and hence either the compresses being forced in equally along its whole length would produce too much widening of it at its centre, or, what is more likely, they would fill it neither above nor below, and hence only partially at the centre. I have therefore long been convinced that the graduated compresses should be applied only at the seat of fracture, and that their length should not be more than one or two inches. M. Nélaton's apparatus is the only one in which this idea is adopted. Besides the advantages already mentioned, there is another which is not unimportant; M. Lenoir, inquiring into the cause of the frequency of gangrene in these fractures, attributes it to the pressure of the apparatus upon the radial and ulnar arteries, which lie directly upon the bone at the lower part of the forearm;* and this pressure is avoided as much as possible by limiting the action of the compresses to the vicinity of the fracture.

Lastly, we should fit also the width of the compresses to that of the interosseous space; this is greatest toward the middle; above and below it narrows greatly, and the compresses, if a little too wide, bear upon the bone on each side without having any effect on the interval between them.

I have hitherto spoken only of graduated compresses, which I prefer in practice. The rolls used by Pouteau would doubtless answer the same purpose; as for M. Nélaton's corks, I should have some fear of their injuring the skin by their hardness.

The splints should be of nearly the same width as the forearm, so as to prevent the bandage from pressing over the bones; above they

* Lenoir, *Thèse inaug.*, Paris, 1833, No. 315, p. 19.

should reach only to the olecranon behind, and to the bend of the elbow in front; and below they should come as far as the wrist. To keep them in place, I prefer to any other means three strips of lead-plaster, which are not apt to become relaxed, and which leave the skin exposed between them. Lastly, the forearm should be put into a sling, embracing the elbow and lightly supporting the hand; it should not be brought in front of the chest, but simply carried at the side, the elbow a little behind and the hand pointing forward; and the ends of the sling should pass one in front and the other behind the body, to meet in a knot over the sound shoulder.

Such is the apparatus which I prefer when there is danger of narrowing of the interosseous space, and especially in cases with overlapping, whether this has been reduced or is irreducible. If the fragments have not become entirely disconnected, and if the interosseous space be but slightly encroached upon, semipronation is more convenient, and may be properly chosen. There is one other case in which it is very suitable, namely, when the injury of the soft parts, or the crushing of the bones, is so great as to render the fusion of the two bones inevitable; it would then indeed be far better for the patient to have the forearm in the middle position than in supination.

When we put the forearm into semipronation, we support it in the same way in a sling, but we should apply its palmar face against the front of the chest, the thumb upward and the little finger downward. But this position involves a new danger, which was accurately studied by Hippocrates, and the reality of which the specimens in our museums show but too plainly. If the sling is so arranged as to press chiefly at the middle, the elbow and hand will fall somewhat, and the fragments will form an angle salient upward, *i.e.*, toward the radial side. If, on the contrary, the hand and elbow are too much supported, the fragments will make an angle salient downward, or toward the ulnar side. The first of these deformities is more common than the second; there are in the Musée Dupuytren three specimens of fracture of the ulna, which have plainly belonged to fractures of the forearm, and in which the fragments form angles toward the radial side varying from 135° to more than 150°.

In view of these facts, Hippocrates enjoins making the sling bear equally upon all points of the forearm, including the wrist. But even then the weight of the hand may tilt up the lower fragment; whence it should also be supported in the sling. Desault did not trust to this, and added two lateral splints to the ordinary apparatus. I own that I would not myself trust to a sling; in even the simplest cases, I much prefer putting the forearm into a pasteboard trough reaching from the elbow down to the roots of the fingers; and in case of need, I should not hesitate to place a solid splint along the ulna and metacarpus.

[The difficulty just spoken of is entirely done away with by the plan adopted in the United States, viz., the use of two straight splints reaching from above the elbow to the ends of the fingers. These are applied to the anterior and posterior faces of the forearm in the semiprone position, being previously carefully padded as advised in the text; and the pressure of the sling being exerted only upon their edges, cannot of course influence the position of the fragments.]

When the fracture is complicated with a wound or with inflammatory swelling, it is best that the patient should keep his bed, the forearm being placed on a pillow, and suitable topical remedies applied. By reason of the weight of the hand and the slight resistance of the pillow, the forearm, at first semipronated, soon passes into complete pronation; and this result is so common that many surgeons do not even try to avoid it, but put the hand at once in the prone position. This position is not mentioned in the books, although very often met with in practice, and presents no advantages to compensate for its inconvenience and danger. We ought in these cases to insure at least a middle position; and this I do by applying to the palmar face of the forearm a thick cushion like those used in fractures of the leg, so that the ulnar border and the cushion together form so wide a surface on the pillow that the pronation of the forearm becomes impossible. The pillow should moreover be so solid as not to allow of the hand sinking into it, and thus forming an angle at the seat of fracture; it is safest to give it firmness by putting a wide board beneath it.

§ II.—*Fractures of the Ulna.*

Fracture of the ulna generally occurs from direct violence, such particularly as a blow warded off with the forearm, which is instinctively pronated, and the ulna thus put immediately in the way. Being by its position and relations removed from the wrist, the ulna would seem likely to escape the action of any indirect cause. M. Voisin has, however, published a case, hitherto unique, of fracture of the ulna from a fall on the palm of the hand; this lesion presented, moreover, an arrangement as singular as its cause; as well as could be ascertained during life, there had been merely a detachment of a longitudinal splinter from the articular facette of the bone; there was no displacement, and the fracture was unrecognised for several days, when M. Voisin having conceived the idea of pronating the forearm, grasped the radius firmly with the left hand, and the lower extremity of the ulna with the right; in this way he easily detected very evident crepitation and mobility.*

* *Gazette Médicale*, 1833, p. 24.

The ulna may be broken at any point in its length; but it is generally the lower third or the middle portion which is affected in preference.

This fracture often occurs without either displacement or crepitation; and then the circumstance of a blow, the swelling, and the persistent local pain, are the only grounds upon which we can base the diagnosis. When there is displacement, it is always the lower fragment which, following the impulse given it by the blow, passes backward, forward, or to the radial side, or in two of these directions at once; the upper fragment is too solidly articulated with the humerus to yield, unless in case of a luxation or a sprain.

The displacement varies in extent; sometimes it is slight, and hardly perceptible; sometimes it is easily recognised, although the fragments may still be in contact; sometimes, lastly, it is complete, when they are entirely separated. In all these cases we find constantly the end of the upper fragment projecting beneath the skin, inward, backward, or more rarely forward, according to the direction in which the lower fragment has been driven. To this incontestable sign of fracture are nearly always added mobility and crepitation; to obtain these we should first fix the radius either in pronation or in supination, and then grasp the upper fragment with one hand, while with the other we seek to move the lower one backward and forward.

The prognosis of this fracture is rarely serious; in fact the displacement is rarely so extensive as to compromise the movements of pronation and supination. Still, slight as it may be, it is excessively difficult of reduction, since we have no purchase for our extension; and when the lower fragment has been driven strongly toward the radius, unless it can be replaced, the rotary movement of the forearm may be destroyed; of this M. Bidart cites an example.*

In order to effect reduction, we are advised to draw upon the hand turned toward the radial side; a plan more plausible in theory than efficient in practice. All our efforts should tend to separate the lower fragment from the radius, the manœuvre required being the same as in fractures of the forearm. As to other displacements, we may diminish them by pressure; but time is generally lost in endeavoring to accomplish complete reduction.

The apparatus is very simple when there is little or no displacement; the forearm should be kept semipronated with two plain splints, in order to prevent the motions of the two bones upon one another, and suspended in an ordinary sling. We may very properly substitute for these two splints a starched or dextrinated bandage; or in the very simplest cases we may merely apply a hollow pasteboard splint, making even the sling unnecessary.

But when the displacement is considerable, and threatens to

* See my *Journal de Chirurgie*, 1845, p. 200.

diminish the interosseous space, we should resort to supination and all the apparatus for fracture of the forearm. Supination is even sometimes necessary, simply to insure the contact and union of the fragments.

M. Fleury has published a curious case of fracture of the ulna treated by semipronation, in which the displaced fragments had not united. He could only keep them in contact by fixing the forearm in supination; and as he wished to use a dextrinated bandage, he used, to maintain supination till the apparatus dried, a very simple means pointed out in my *Anatomie Chirurgicale*, viz., two small transverse splints properly fastened a little above the wrist. The apparatus being removed at the end of forty days, the ulna was found to be solid, and the limb, although at first very stiff, ultimately recovered its movements entirely.*

Compound fractures of the ulna are much less serious than those of the forearm, since the radius acts as a splint, and of itself suffices to hinder mobility or displacement. M. A. Bérard had to treat a comminuted fracture of the lower fourth of the ulna, with division of the muscles before and behind it, and of the ulnar artery and nerve; he tied both ends of the artery, dressed the wound, placed the forearm first upon cushions and afterwards in the ordinary apparatus for fracture of both bones, and succeeded in obtaining, at the end of sixty-eight days, complete consolidation and cicatrisation.†

§ III.—*Fractures of the Shaft of the Radius.*

The radius alone may be broken at any point in its length; but setting aside fractures of its lower extremity, those of its shaft are less frequent than those of the shaft of the ulna. Sir A. Cooper has raised some doubts as to the reality of fractures of the neck of the radius. I once believed that I had several times seen it in children carelessly lifted by the wrist; but experiments on the dead body have shown me that in these cases there was rather subluxation than fracture. I shall again refer to this interesting point in connection with dislocations of the radius.

Fractures of the body of the bone are produced sometimes by direct causes, but oftener by falls on the hand. Van Niérop has cited a case in which muscular action seemed to play the most important part; it was that of a woman aged 30, who having wrung out two large sheets, felt a very sharp pain in the forearm; he detected a fracture in the lower third of the radius.‡

* *Journal de Chirurgie*, 1845, p. 314.
† *Gazette Médicale*, 1833, p. 403.
‡ *Gazette des Hôpitaux*, 1844, p. 224.

[In April, 1856, I saw a case in the Baltimore Infirmary, under the care of Dr. Miltonberger, in which the symptoms of fracture of the radius high up were very well marked; the man had felt something give way while he was pulling violently in driving a pair of young horses.]

The symptoms are variable. Sometimes the fragments remain interlocked; and then the only signs of the fracture are, the pain developed locally by pressure or by any movement, and perhaps bending of the bone at a certain point under strong pressure. In other cases the external violence drives in toward the ulna either one fragment, as in *Fig.* 50, or both, as in *Fig.* 53. In the latter, indeed, the ulna is fractured also, but since its fragments have remained in position, the fact does not affect the displacement in the case of the radius. Lastly, when a blow falls directly on the dorsal or palmar face of the bone, one of the fragments may be driven either in front or behind the other. In all cases, besides the pain, we may by the touch recognise the existence and character of the displacement; and by fixing the upper fragment with the fingers, and then pronating and supinating the hand, we may easily elicit distinct crepitation.

But there is one other form of displacement, thought by Boyer to be impossible, and which occurs under very different circumstances; I allude to overlapping. Sometimes it is only partial, so to speak, and shortens only the outer edge of the bone; as when it results from the lower fragment being driven in toward the ulna. *Fig.* 50 shows this condition extremely well. The inner part of the articular surface of the radius has remained almost in its place, while the styloid process has been drawn up to the level of that of the ulna, than which it is notably lower in the normal state of things. This kind of overlapping by inclination is naturally quite limited, since the inclination itself is limited by the contact of the lower fragment with the ulna; and for the same reason it is less in proportion as the fracture has occurred higher up, and greater in proportion as the lower fragment, being shorter, describes a larger arc. But sometimes there is added to this a direct overlapping, the lower fragment slipping upward along the ulna, which remains luxated inward, as seen in *Fig.* 53. Lastly, the overlapping may be still more marked, the luxated ulna protruding through the integuments; the fracture of the radius is then either comminuted or multiple; but this belongs more especially to the subject of luxations of the ulna.

It will be seen that in cases where the overlapping is slightest, there is spreading, or *diastasis*, of the lower articulation of the two bones; and that hence the wrist is somewhat widened, the distance between the two styloid processes being increased, as was stated by Pouteau. But this author conceived that depression of the fragments of the radius toward the ulna should increase the length of

the radius, by effacing its natural curvature;* an idea which, although very specious theoretically, has never been proven by practice.

The diagnosis commonly offers very little difficulty. Desault was the first to point out, as a possible source of error, the crackling of the tendons of the extensors of the thumb in case of inflammation of their sheath, which might be mistaken for the crepitation of a fracture by an inexperienced surgeon; but besides that this sound is very different from bony crepitus, it only occurs when those muscles are put into action, and not when motion is imparted merely to the bone.

The prognosis, in properly treated cases, is quite favorable. Thirty days will suffice for union to occur.

The treatment is based on nearly the same indications as that of fractures of the forearm. When however the lower fragment is driven in toward the ulna, besides the methods already pointed out for restoring the interosseous space, the integrity of the ulna affords us another, namely, traction on the hand in a state of extreme abduction. We thus overcome the spreading of the two bones at the wrist-joint; we bring the styloid process inward, and consequently downward, and thus necessarily tend to carry outward the end of the upper fragment. Actual overlapping, with luxation of the ulna, would require direct extension to be previously made.

Reduction once accomplished, it is generally sufficient to arrange along the interosseous space graduated compresses, supported by splints; I need not dwell upon the different forms of apparatus, which are the same as those described for fractures of the forearm. I must however allude here to a contrivance of M. Baudens, intended especially for fractures of the radius. It consists of a nearly semi-elliptical steel spring, with each end rounded so as to press into the interosseous space before and behind. In order to guard against excoriation, we first apply two little splints about an inch and a half long and an inch wide, properly padded, upon which the two ends of the instrument may press. As this does not insure the immobility of the limb, M. Baudens employs also a box, with loops and cushions; making a heavy and complicated apparatus.† The two splints answer our purpose much better.

In more difficult cases, it may become necessary to keep the hand forcibly abducted, and perhaps even to make permanent extension. But the appliances for meeting this double indication having been mainly devised for fractures of the lower extremity of the bone, I shall postpone their description to the next section.

* Pouteau, *Mém. contenant quelques réflex. sur les fract. de l'avant-bras*, etc.; *Œuvres Posth.*, tome ii, p. 251.

† *Gazette des Hôpitaux*, 1844, p. 505.

§ IV.—*Fractures of the Lower Extremity of the Radius.*

These fractures, hardly noticed by the ancients, but described with some care by Pouteau and Desault, have been especially studied in our own times by Sir A. Cooper, Dupuytren, MM. Goyrand, Diday, and Voillemier; and I have myself likewise devoted some attention to their investigation.*

The first question which arises is as to their frequency. M. Goyrand has asserted that they are to all other fractures put together as one to two; Dupuytren gives them in this respect, if not the first, at least the second or third rank. But these exaggerated statements are set aside by facts. Without arguing from my figures derived from the Hôtel-Dieu, which upon this point are not sufficiently exact, I have before me a table of the cases treated in one ward by Dupuytren in the year 1818: of 81 fractures there were but four of the radius; in 1827, a corresponding table shows sixteen out of 109; in 1828, five out of 110; in January, 1830, sixteen out of 101; and putting these four proportions together, we have a total of forty-one out of 401,—one-tenth. In the last year of my service at the Hôpital Saint-Antoine, from January 1 to August 1, 1844, among sixty-seven fractures, I met with seven of the lower extremity of the radius,—a ratio nearly the same as above.

I pass over the influences of sex and of age here, as they were sufficiently dwelt upon at the beginning of this chapter.

This fracture is rarely due to direct violence; although M. Hublier has communicated to the *Académie de Médecine* the case of a young girl, who, having had her wrist caught between a wall and a carriage-pole, had a transverse fracture of the lower end of the radius, with a vertical fracture dividing the lower fragment into two parts.† But the most frequent cause is a fall on the palm of the hand, and next to this a fall on the back of the hand; of fourteen fractures observed at the Hôtel-Dieu in January, 1830, three were induced in the manner last mentioned.

By what mechanism do these falls give rise to fractures of the lower end of the radius? It may be alleged first that the bone, being caught between two forces, the weight of the body acting on its upper end and the resistance of the ground on the lower, tends to give way where it is weakest, namely, at the point where the compact tissue ends; and this theory seems to be established

* Pouteau, *op. cit.*; Goyrand, *Premier Mémoire; Gazette Méd.*, 1832, p. 664; *Deuxième Mémoire, Journ. Hebdomad.*, Feb., 1836; Malgaigne, *Mémoire sur les lux. du poignet*, etc.; *Gazette Méd.*, 1832, p. 730; Diday, *Archiv. Gén. de Médecine*, 1837, tome xiii, p. 141; and Voillemier, *ibid.*, 1842, tome xiii, p. 261.

† *Archiv. Gén. de Médecine*, tome xx, p. 291.

by the following experiments. M. Nélaton amputated the forearm of a dead body at the elbow, and resected the olecranon; then, applying the palm of the hand upon a solid surface, the forearm being kept vertical, he struck a heavy blow upon the upper ends of the two bones. The wrist cracked, and became deformed, and dissection revealed a simple transverse fracture at the extremity of the radius, the lower fragment being thrown backward. I make no doubt that in a very large number of cases this is the mechanism of the fracture. Sometimes again it seems as though the bone, without bending, were crushed between the two forces, as in a vice; M. Voillemier has given a representation of a case in which the upper fragment, rounded at its edges, was driven nearly three inches into the spongy tissue of the lower, and had broken the articulating portion into four pieces.

Lastly, there are cases, perhaps more numerous than would be supposed, in which the wrist does not touch the ground, and the bone does not yield to the two forces acting in contrary directions, as before described; but by an exaggerated flexion of the hand forward or backward, the extremity of the radius, following the movement, is torn away from the rest of the bone. M. Bouchet was the first to establish this idea; in trying to dislocate the wrist in the dead subject, he only succeeded in producing fractures of the lower extremity of the radius, sometimes with other lesions, and especially with fracture of the styloid process of the ulna.* M. Voillemier had two opportunities of observing analogous fractures in the living subject; in one case a man had fallen upon the lower half of the hand, not upon its "heel;" in the other the patient had not fallen at all, but a comrade had forced his wrist into immoderate flexion; here the conditions were exactly the same as in M. Bouchet's experiments.

We see from the foregoing that this fracture may exist by itself, or complicated with another entering the joint, or with crushing of the lower fragment and its articular face, or lastly, with a tearing away of the styloid process of the ulna. It remains for us to study the disposition of the principal fracture, and the nature of its different displacements.

One word first as to their seat. According to Dupuytren this may be three to six lines, or even an inch, from the articular surface. Sir A. Cooper states that it is generally an inch above the styloid process; M. Nélaton, about half an inch above the anterior edge of the bone. There may doubtless be slight variations, owing to the age and stature of the subjects, which influence the length of the radius; or from the crushing of the lower fragment, or the length of the serrations on its upper edge. But upon dissection, the principal division of the bone has always seemed to me to be at nearly

* Bouchet, *Thèse sur les lux. du poignet*, Paris, July, 1834.

the same point, namely, just where the compact tissue of the shaft gives place to the true spongy tissue of the end. And as it takes a transverse direction, the fracture is more or less distant from the joint, according to the point where we examine it; thus in *Fig.* 54, the fracture, if examined in front and on the inner side, is not more than one-third of an inch from the articulation; examined behind, *Fig.* 55, the interval is about twice as great, and if measured upward from the styloid process, it amounts to nearly a full inch.

I have said that the fracture is generally transverse; M. Voillemier was the first to prove, contrary to the statements of preceding authors, that there does not exist an instance in which it is oblique; and I would add that for my own part I know of no oblique fractures in this region except such as pass into the joint, which will come up again in connection with luxations of the wrist. [At the end of the present chapter will be found a note upon this subject.] But because the fracture divides the bone transversely, it is not necessarily any more even; we see in *Figs.* 54 and 55, numerous serrations about the edges of a recent fracture; and in *Fig.* 56 they are still more clearly shown. M. Voillemier has represented them more than a third of an inch in length; and in one of his specimens, one of the serrations, detached at its base, is transformed into a splinter.

Sometimes, and indeed not very rarely, there is no appreciable displacement. The patient feels severe pains in the wrist, increased by pressure or by motion; and except a slight swelling, perceived especially in front, there is no deformity; so that we might be led to think the injury a mere sprain. But if pressure is made directly over the line of the articulation, little or no pain is caused, while about an inch above this the pain is very severe; and we obtain a pathognomonic sign by putting the thumb behind the supposed seat of fracture, and trying to bend the bone at this point so as to make an angle forward; a comparison of the two wrists will now place the matter beyond a doubt.

We must not, however, assume, because there is no appreciable displacement, that there is none in reality. The specimen represented in *Figs.* 54, 55 and 56 was taken from a woman of seventy, who died on the fourteenth day after her accident, of pneumonia; this had prevented the reparative process, so that the fracture was in appearance a very recent one. The upper fragment is seen to be moved on the other about one-thirtieth of an inch forward, and about one-eighth or one-sixth of an inch inward. The swelling, however, entirely masked this slight displacement; there was no crepitation, nor mobility from side to side; and M. Maisonneuve, who sent me the account and the specimen, only arrived at the diagnosis by bending the forearm in the manner mentioned. The injury was produced by a fall on the wrist; the periosteum was entirely torn across in

front, but posteriorly it remained intact; which explains the greater facility of separating the fragments, and of bending the forearm to a right angle, in front than behind.

In other cases this angle exists already, serving of itself to point out the fracture, even when the swelling would prevent our detecting the slight prominence formed posteriorly by the lower fragment; this I have seen in a good many instances. We must not suppose that the angle thus visible at the palmar face of the forearm is formed by the fragments themselves; their line of separation occurs just where the anterior surface of the bone ceases to be vertical, by curving forward. When we try to bend the limb at this part, we hardly do anything but restore the natural concavity of the bone; but the soft parts lodged in the interspace then necessarily make an abnormal prominence in front; and hence I say that the angle is formed by the forearm, and not by the radius itself.

In an another variety, which seems also to be quite common, the lower fragment projects backward and the upper forward, so that the forearm and hand nearly resemble, according to M. Velpeau's apt comparison, the back of a silver fork; a superficial examination might lead us to suspect a luxation backward of the wrist. It is hardly the case then that the lower fragment makes an angle with the other; the articular surface of the radius has only sustained a rotation backward to an almost imperceptible degree; the styloid process remains almost exactly at its normal level, and the relations of the hand with the ulna are not sensibly altered. The projection forward of the upper fragment, however, is much less marked than that of the lower one backward, owing partly to the inclination of the latter, slight as it may be, and partly to the penetration of the latter into the spongy tissue of the former; in one of M. Voillemier's figures (No. 3, pl. ii,) these circumstances are accurately rendered. The backward displacement of the lower fragment must be very considerable in order for us to perceive the projection forward of the lower end of the ulna, a sort of slight luxation which will be again mentioned in due time.

Lastly, we meet with cases in which in the first place the lower fragment projects backward, giving the wrist an appearance to be presently described; but moreover, the hand is drawn toward the radial side, and the lower end of the ulna makes a more or less marked prominence inward. The mechanism of this displacement is hitherto unexplained. Pouteau thought that the lower fragment was drawn inward by the pronator quadratus, so as to lessen the interosseous space and tilt outward the styloid process. But M. Voillemier justly observes that there is no interosseous space at the level of the fracture; he ascribes the displacement to the great force sustained in the fall by the outer half of the wrist, and to the deeper penetration of the upper fragment on the side corresponding to the

styloid process. I would not deny the possibility of this being the mechanism; but it is not what my observations so far have shown me; in my opinion, the displacement in question depends essentially on a tilting backward and upward of the lower fragment, the upper one being deeply penetrated posteriorly, and the two remaining merely in contact in front. This view is completely illustrated in *Figs.* 57, 58 and 59.

We see first in *Fig.* 57 the anterior faces of the two fragments to be nearly in the same vertical plane, while posteriorly the lower one projects about one-quarter of an inch; the styloid process is on the same level with the anterior edge of the articular surface, but much below the posterior. All this is made still clearer in *Figs.* 58 and 59.

These two figures represent a specimen removed from an old man at Bicêtre, whose fracture, one of long standing, was unreduced. *Fig.* 58 shows the posterior aspect of the radius and ulna; the styloid process of the radius is nearly on the same plane with the anterior edge of the articular face, and with the styloid process of the ulna itself. The posterior edge is, on the contrary, remarkably elevated, so that the articular face looks downward and backward, whereas in its normal state it looks downward and forward. In *Fig.* 59 the radius has been sawed vertically, and we have a still better view, showing at once the flattening of the anterior surface, the projection backward of the lower fragment, and the singular distortion of the articular face. Thus the styloid process is not thrown outward; it has only described, along with the whole lower fragment, an arc of a circle, carrying it up backward, and making its apex actually point as much backward as downward. This arc could not be described without some derangement of the radio-ulnar articulation, the cavity at the side of the radius offering obliquely to the head of the ulna, which continues horizontal; whence arises an altogether peculiar separation of the two articular surfaces, a new species of diastasis, very different from that which sometimes occurs in fractures of the shaft of the radius. The stretched ligaments have pulled upon and torn away the styloid process of the ulna; and lastly, this bone, passing down posteriorly a little below the radius, loses its connection with the carpus, which maintains its radial articulation. There are cases in which the ulna is actually dislocated, either forward or backward; I shall postpone the consideration of these until we take up the subject of luxations.

Let me say lastly a few words concerning displacement forward, which is very rare; I have never had an opportunity of observing it. I have quoted in my *Mémoire sur les luxations du poignet*, a case given by M. Cruveilhier as an example of radio-carpal luxation, in which there was merely a fracture of the radius with displacement forward of the lower fragment; and with the drawing only before

me, I presumed that there had been a separation of the epiphysis, this being thrown *en masse* in front of the radius. The complete turning forward of the articular face authorised such a conjecture; but in a case in which this was much less marked, M. Voillemier showed that the anterior wall of the shaft had penetrated the spongy tissue of the lower fragment, exactly as the posterior wall does in cases of displacement backward.

This penetration is unmistakable in the preparation, if we divide the radius by a vertical section from before backward; and I cannot account for its having escaped the notice of M. Diday. In *Fig.* 59 we see the compact wall of the diaphysis driven nearly an inch into the spongy tissue; but we must here take notice that this great penetration is more apparent than real. All above the projecting angle of the lower fragment belongs to the uniting callus, so that the actual penetration is reduced to a few millimètres. This is clearly shown in *Fig.* 57, representing a fracture not entirely consolidated; all the posterior portion of the callus having been removed by maceration, we see exposed the projecting angle of the lower fragment, and the space between it and the diaphysis; this space was filled with the callus, some traces of which are found about two-thirds of an inch higher up.

Such are the principal aspects of fracture of the lower extremity of the radius, whether during life or upon dissection. I may add that it is very often complicated with fracture of the styloid process of the ulna; but this generally retains its place, or is at the most drawn slightly outward. (See *Fig.* 58.) There remains now, to complete the subject, the study of a few special symptoms.

Crepitation is generally wanting; which seems to me owing to the absence of mobility from side to side. Since, in fact, the fragments do not move except by forming an angle, there is no perceptible rubbing together of them, and hence no crepitation; but this appears at once when there is mobility, and especially when there are splinters.

The deformity is often masked by the swelling. It is well to recollect that the projection of the lower fragment backward, due to its penetration by the other, is generally more masked than that of the latter forward; for this is what has deceived some observers into an over-estimate of the obliquity. This displacement has also the effect, by increasing the antero-posterior diameter, of giving a cylindrical form to the lower portion of the forearm, and thus leads sometimes to the erroneous idea that the transverse diameter is diminished.

Such diminution of the transverse diameter may, however, actually occur, by a mechanism hitherto unexplained, as seen in *Fig.* 2; the upper fragment approaches the ulna, while the lower maintains its position. Pouteau likewise pointed out a widening of the wrist between the styloid processes; I have already mentioned how such a

widening may result from a *diastasis* of the radio-ulnar articulation; it is still more marked in cases of crushing of the articular end of the radius, which naturally throws its styloid process outward. But these two symptoms are rare, never well-marked, and detected with difficulty during life, on account of the thickness and swelling of the soft parts.

Lastly, a word must be said as to this swelling, which presents a particularly remarkable aspect on the anterior face of the forearm. J. L. Petit ascribes it to sanguineous, œdematous, or inflammatory infiltration in the areolar tissue over the pronator quadratus; Bertrandi, to the tearing of the muscles and their compression by the fasciæ. Pouteau advances the idea that it is due to contraction of the pronator quadratus; Sir A. Cooper seems to attribute it to the projection of the fragments themselves. I think, for my own part, that the chief source of the swelling is in the first place from extravasation of blood, and subsequently from inflammation, occurring in the cellular tissue and in the sheaths of the tendons; which explains its predilection for the anterior surface.

The consequences of these fractures, when they are misunderstood or improperly treated, are quite serious. Deformity of the forearm, impairment of pronation and supination, as well as of flexion of the wrist and hand, and feebleness of the fingers in prehension; long-persistent swelling and pain; sometimes obstinate stiffening of the joint, or even inflammation and its consequences, may be mentioned. Lastly, M. Goyrand has seen permanent contraction of the fingers as a consequence of this fracture.

The diagnosis is now rendered so easy, by slight study of the relations of the styloid processes and the level of the osseous prominences, by the seat of the pain, and lastly by the abnormal bending of the bone at the point of injury, that it is no longer excusable for any surgeon to err in regard to it. We should bear in mind, however, that it has long been liable to be mistaken for a dislocation or a sprain, and that Dupuytren first succeeded in correcting this error. I shall recur to the differential diagnosis in treating of the above injuries. The slight fracture of the styloid process of the ulna often goes unrecognised; it may be suspected from the pain caused by pressure over it.

The prognosis is extremely favorable when the fracture is recognised in time, and when there is only a displacement of the lower fragment backward. But if the styloid process is carried up a good deal above its natural position, and if the hand has departed a good deal from the ulna, deviating outward, it will be very difficult even to lessen this abduction, and almost impossible to overcome it entirely. Deformity is likewise inevitable when the articular end of the bone is crushed.

The treatment varies according as there is or is not displacement,

and if there is any, according to its nature and extent. If there is none, two splints, or a dextrinated bandage, will be sufficient; but when it does exist, it gives rise to indications for the fulfilment of which numerous means have been devised. The three objects hitherto aimed at are (1) the restoration of the interosseous space; (2) the correction of the displacement backward (or forward) of the inferior fragment; (3) the correction of the abduction of the hand, by bringing the styloid process down to its natural level.

First Indication; to restore the Interosseous Space.—This is what was sought by Pouteau with his rolls of linen, by Desault with his graduated compresses, and by M. Baudens with his steel spring. Now, as there is no interosseous space at the level of the lower fragment; as the upper fragment is only very rarely carried inward, and even then does not sensibly compromise the interosseous space; as, finally, this slight displacement, very difficult of detection in the living subject, would probably be still more difficult to overcome, this first indication falls to the ground, and need not be further dwelt upon.

Second Indication; to correct the Displacement backward.—The reduction of this displacement, when it exists by itself, requires only moderate extension; one assistant draws upon the hand, while another holds the forearm, and the surgeon, putting the fingers of both hands over the angle or fragment in front, pushes forward with the thumbs the posterior fragment; in most cases even extension is unnecessary. It now remains to keep up the reduction thus made.

Sir A. Cooper was the first to treat of this. He applied two small pads, one in front over the wrist, and the other behind over the back of the hand, binding them on with a roller, and making pressure through them by means of two splints reaching from the elbow to the end of the metacarpus.

M. Goyrand's first apparatus somewhat resembled that of Sir A. Cooper. It consisted of two small pads, the anterior of which, an inch in length, was placed just above the bend of the wrist, while the posterior came down over the metacarpus. So also the two splints came just as far as the ends of these pads. Subsequently M. Goyrand improved his anterior pad by making it thicker above than below, so as to exert less pressure on the anterior edge of the articular surface of the radius.

It is too evident that this anterior pad, descending just as far as the wrist, tends to press the lower fragment backward, while all its action in this direction should bear upon the upper fragment. As for the posterior pad, it needs only to act on the lower fragment, without extending over the back of the hand; in fact, there is an actual inconvenience in thus prolonging it, from its holding the hand in an unnatural position, and hence stretching the extensor muscles, and favoring stiffening of the joints. I have therefore for many

years employed the following simple apparatus, and with constant success.*

With two compresses, from eight to sixteen times doubled, I make two pads three fingers'-breadths long, and as wide as the forearm; I arrange one transversely, just over the anterior fragment, and the other over the posterior fragment, taking care that it never extends down so far as to prevent the habitual flexion of the wrist backward. I then apply in front and behind two properly padded splints, making them press firmly upon the two pads, and not allowing either of them to go beyond the wrist; the anterior one alone should reach a little beyond the corresponding pad, by which its extremity is kept too far removed from the wrist for it to do any harm; this slight prolongation is necessary to insure the action of the posterior splint. The whole is kept in place either by a roller made to cover the splints in their entire extent, and if necessary stiffened with albumen or dextrine, or by three strips of lead-plaster, between which the skin is left exposed to view. The forearm is finally suspended in a sling, in the middle position; that is to say, resting on its ulnar border.

Third Indication; to correct the Abduction of the Hand.—This was first pointed out by Cline; and the mode proposed by him for its fulfilment has at least the merit of great simplicity. The forearm, placed between two splints, was hung in a sling which reached no farther than the wrist; and the hand hung by its own weight toward the ulnar side, or in other words, in the position of adduction.

Dupuytren sought the same end, but by more energetic means. To the ordinary apparatus for fractures of the forearm he added his *ulnar splint*, made of a bit of iron an inch in width, greatly curved in the arc of a circle opposite the wrist, and furnished with knobs on its concave surface. This splint was applied along the ulna, being held off from the wrist by means of a small cushion of oat-bran, or by thick compresses, and fixed with a roller. Then the ulnar border of the hand was fitted to its convexity, so as to be brought into forcible adduction, and maintained thus by a bandage, or by a mere loop; care being taken, however, to protect the index-finger by a small pad or compress, lest the pressure of the loop should produce excoriation. The knobs on the concave surface of the splint were intended to fasten each turn of the bandage at the proper height. The attempt has been made to substitute for this iron splint wooden ones, which should first cover the forearm in the ordinary way, and which at the wrist should bend sharply inward, not by their surfaces, but by their edges. M. Blandin has proposed this kind of splint, which was, however, previously known.†

* See my Memoir, already quoted, and the *Gazette des Hôpitaux*, Jan. 15, 1839.

† *Gazette des Hôpitaux*, Oct. 8, 1836. These splints had been mentioned in the *Gazette Médicale*, April 9, 1836, p. 234.

M. Dumesnil has devised an apparatus more easily to be procured, since it requires only ordinary splints and bandages. The two splints, one and a half to two inches in width, should reach from above the elbow to beyond the finger-ends. They are confined by means of a roller extending from the wrist to the bend of the elbow. "There, in place of carrying the roller around the entire circumference of the arm, two or three figure-of-8 turns are made to embrace the upper ends of the splints; after which the bandage is exhausted in complete turns." The first roller being thus disposed of, a small bandage is applied by its middle portion over the radial border of the hand, at the level of the metacarpal bone of the thumb; its two ends are brought over to the ulnar border, being passed between the hand and the splints; and each end being again brought over the outer face of the corresponding splint, the two are fastened together by a double knot over the radial edge of one or the other splint. The middle of this band serves to adduct the hand, taking its *point d'appui* at the ulnar edge of both splints, which represent, as it were, pulleys.*

These contrivances having been but partially successful, permanent extension was proposed. The idea occurred simultaneously, about ten years ago, to M. Godin and M. Diday; they devised for the purpose some plans, of which there remains only the bare mention by the latter; and the only two apparatuses at present known are those of M. Huguier and M. Velpeau.

M. Huguier, considering the fact that the hand and forearm present two cones connected by their summits, sought in the first place to take his *points d'appui* at the widest parts of these cones. He therefore covers the wrist and hand with a sort of glove, by means of a bandage, the turns of which hold in place four loops, two in front and two behind; these loops are brought down over the fingers, and meant for making extension. The forearm is now covered by a soft dry bandage; above this are placed two graduated compresses before and behind over the interosseous space, but ending about two-thirds of an inch above the wrist, so as not to bear upon the prominences of the radius. Lastly come two splints, differing in three points from those in common use; in the first place their edges are notched, to prevent their slipping beneath the bandage confining them, and to secure counter-extension by keeping them up in their places; secondly, they reach beyond the ends of the fingers, and have at their extremities upright tenons for the attachment of the extending loops; and thirdly, they should be cut out at their upper ends, so as to receive other splints applied to the arm itself. Thus, we put in front of the arm a pasteboard splint bent at the elbow, so as to come down on the forearm, and over this latter a wooden splint

* *Gazette des Hôpitaux*, Dec. 21, 1841.

reaching up only to the bend of the elbow. On the posterior face of the arm we put another wooden splint, reaching a little below the olecranon. In this way we give the forearm splints a more solid *point d'appui* than is afforded by the tissues of the forearm, which soon become excoriated from the combined effect of pressure and want of action.

M. Velpeau fixes in a nearly similar manner two bits of bandage in the shape of loops, to make extension; but for counter-extension he applies to the elbow a sort of boot-top, by which is confined a loop; both these preliminary bandages are imbued with dextrine, to give them firmness. It only remains to draw these loops tight, and fasten them to the two ends of a splint, somewhat longer than the forearm, and terminating in a perpendicular stem.*

Without dwelling further upon the comparative value of these two methods, I should fear that either of them would be too painful to be borne; and M. Diday informs us that in the trials he made of them, the suffering caused by making extension was so great that he was obliged to abandon them. But the strongest objection lies in the fact that the overlapping itself is in most instances merely due to the tilting backward of the lower fragment; whence in fact the only indication is to push this forward. If to this tilting backward there is joined a real separation outward of the styloid process, with projection inward of the ulna, two new indications arise, namely, to push the latter outward, and at the same time to replace the former inward. Permanent extension can do nothing here; the sling invented by Cline is useless; splints with curved edges, and M. Dumesnil's apparatus, have the serious defect of not pressing the ulna toward the radius. Dupuytren's ulnar splint is the only one which would fulfil this indication, but Dupuytren, and all who have followed him, have missed their aim by acting upon the hand itself in making the adduction; so that the two forces which should approximate the radius and ulna not being directly opposed to one another, their due effect is lost, and the ulna remains always more than naturally prominent. It should be borne in mind that the hand gets its improper position by following the inferior fragment, and that it is this fragment which needs restoration. I think therefore that we should be more certain of success with two lateral splints, acting like the dorsal and palmar splints in displacement backward; the one on the radial side should bear on the lower fragment by means of a pad, so as to press it inward; the other in the same manner should push outward the lower end of the ulna, while the hand should be left to its own gravity outside of the sling, according to the practice of Cline and of Sir A. Cooper.

Whatever apparatus we may have recourse to, it is important for

* *Gazette des Hôpitaux*, 1842, p. 27.

us to guard against stiffening of the wrist and fingers, which is a very common sequel of this fracture. For this reason, I do not allow the splints to reach beyond the first row of the carpal bones, but leave the hand free and completely relaxed, the metacarpus flexed backward, and the fingers forward; in order thus to be able to impress upon all the joints moderate motion, which may be done without the slightest difficulty.

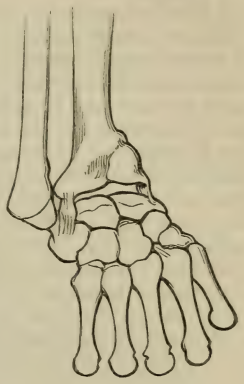
I remove the apparatus at the eighteenth to the twenty-second day, to ascertain the condition of things, and to remedy any displacement which may have occurred; after this I do not touch it until the thirtieth day, when I leave the limb entirely at liberty. I would repeat that by pursuing this method I have always found this fracture one of the easiest to cure, without stiffening, deformity, or the slightest impairment of the functions of the limb; excepting, of course, in those very grave cases complicated with actual luxation of the ulna, to which reference will be made hereafter.

Before concluding this subject, I would say a few words concerning separation of the epiphysis of the radius, which forms perhaps the most frequent instance of that class of injuries. M. J. Cloquet ascertained it by dissection in a child of twelve; M. Roux in a child, age not given; Johnston, in a young man of eighteen;* and lastly, M. Voillemier produced it with great facility in the dead body, by making forcible flexion or extension of the wrist, not only in very young subjects, but in a robust man of twenty-four. The causes, symptoms, and treatment are identical with those of the veritable fracture; but we have reason to suspect this separation rather than fracture in patients under twenty years of age.

[In 1840, Dr. John Rhea Barton, of Philadelphia, published, in Hays' *American Journal of the Medical Sciences*, an account of a form of fracture in which the styloid process of the radius is chipped off, and the articular face of the bone of course divided. It is nearly always the result of indirect violence, is of very frequent occurrence, and entails consequences so immediately traceable to the fracture itself as to make this the proper place for its description. The hand is pronated and flexed on the forearm by its own weight as well as by the action of the flexor muscles; and the fragment is thus as it were squeezed upward into a deformity at the back of the wrist. At the same time the muscles of the thumb, and the flexor carpi radialis, draw the radial side of the hand upward, causing the ulna to project, the carpal bones departing from it. To these causes of deformity there is sooner or later added effusion into the carpal bursæ, or into the joint, or both. (This effusion ensues also upon fractures more nearly transverse, when the prolongation of the synovial mem-

* J. Cloquet, *Dict. de Méd.* en 30 vols., art. *Fractures de l'avant-bras;* Roux, *Thèse de M. Galand*, Paris, July, 1834; Johnston, *Bulletin de la Soc. Anatomique*, 1839, p. 189.

brane upward between the radius and ulna is injured.) For obvious reasons the distortion is greater than in the transverse fracture higher up, described by Colles. The line of separation may often be clearly traced with the fingers; its direction is seen in the annexed drawing, which Dr. Henry H. Smith has kindly allowed me to make from a specimen in his collection. An analogous preparation is in the possession of Dr. Edward Peace, of this city. (In Dr. Smith's preparation a small portion of the lower end of the ulna is also separated. No history of the case can be obtained.)



In the treatment of this injury, Dr. Barton advised the use of two compresses, a dorsal and a palmar, so arranged as to press the fragments into place, and of two splints, likewise dorsal and palmar, reaching from the elbow to the ends of the fingers; he also recommended that passive motion should be made after the third or fourth day.

In 1852, Dr. Henry Bond, of Philadelphia, proposed a new form of splint for this fracture. (See the *Am. Journ. of the Med. Sc.*, 1852, p. 566.) It is easily made by cutting out a thin piece of board, such as the lid of a cigar-box, in the shape of the sound limb, so as to reach from the elbow to the second joint of the fingers. This piece of board is now turned over, and a block of soft wood of suitable size and shape is so fitted to it as to be grasped by the fingers of the injured hand. A roller, or a piece of cotton cloth, is now made to envelope the splint, to which may be added sides, of leather or pasteboard. (See Cut.) The splint thus made being well padded, the forearm laid in it, a roller is applied, and the whole placed in a sling, the thumb being carefully kept upward. Passive motion may be made very early, and in a great many cases a cure is effected without the slightest trace of deformity. Some caution must however be observed in leaving

off the splint, as if this be done too early the deformity is sure to recur; five weeks is the very shortest time allowable.

The advantages ascribed to this method by Dr. Bond are realised constantly in the practice of very many American surgeons. They are as follows:—

(1.) The inclination of the hand toward the ulnar side, as in M. Nélaton's *attelle cubitale.*

(2.) Relaxing the muscles, by keeping the wrist in its most usual position,—flexion backward; keeping the fingers in a state of comfortable flexion; and if stiffening is unavoidable, preserving some degree of usefulness of the member.

(3.) Keeping the whole apparatus firm, by pinning the roller to the muslin envelope of the wooden splint.

This splint may be used with advantage in other fractures of the forearm also, either with or without the addition of a dorsal compress or splint. Dr. Robert P. Harris, of this city, tells me that he has modified the palmar block, making it convex from side to side above, so as to fit better to the palm of the hand; he has also derived advantage from the use of a thin pad filling up the hollow at the radial side of the front of the forearm, just above the wrist.]

CHAPTER XIV.

FRACTURES OF THE BONES OF THE HAND.

Fractures of the hand present in the first place this remarkable peculiarity, that they occur almost exclusively in men; we shall see in studying them separately how rare they are in women.

They all have also this point of resemblance: that very often, and perhaps most commonly, they result from direct causes of such a violent character that not only the bones but the soft parts are bruised and lacerated, and so injured as to make the fracture a mere epiphenomenon. Such is apt to be the case when the hand is crushed by a carriage-wheel, caught in a machine, or wounded by gunshot, and especially when a firearm bursts in the hand. I shall not dwell on these grave injuries in which amputation is commonly necessary, and which belong rather among complicated [or compound] fractures. We have here to study only simple fractures, or those with such slight complications as do not materially modify the indications for treatment.

Fractures of the hand may be classed under three heads: those of the carpal bones; those of the metacarpal bones; and those of the phalanges.

§ I.—*Fractures of the Carpal Bones.*

These fractures are extremely rare unless we include among them cases of crushing, and are almost always due to direct causes. It is indeed matter of surprise that falls on the hand, from which so many fractures of the radius result, so seldom give rise to the injury in question. The carpus does not however always escape. M. Bouchet, in making forcible flexion and extension of the hand in the dead body, found among the other lesions one or more fractures of the bones of the wrist; M. J. Cloquet met with them in two autopsies upon persons who had sustained falls on the wrist; and M. Jarjavay lately detected a fracture of the scaphoid from a similar cause.*

In M. J. Cloquet's two cases, the swelling of the soft parts had

* Bouchet, *op. cit.*, Paris, July, 1834; J. Cloquet, art. *Main*, in the *Dict. de Méd.* en 30 vols.; Jarjavay, *Thèse inaug.*, Paris, 1846, p. 25.

prevented the detection of the fractures during life; and it would seem to have been so in M. Jarjavay's patient also. It is therefore to be presumed that most commonly the fracture is revealed only by the crepitation; but care is required lest we mistake its seat, and improperly suppose it to affect the radius. The treatment should consist essentially in keeping the wrist at perfect rest, with the precaution however of making passive motion from time to time, to prevent stiffening of the joint.

§ II.—*Fractures of the Metacarpal Bones.*

These fractures are not frequent, as may be seen from their small number,—sixteen,—in our total of cases at the Hôtel-Dieu.

They are met with almost exclusively in males; of the sixteen cases at the Hôtel-Dieu, but one was a woman; I have myself observed five cases in men, and only one in a woman; and it will be seen that all the cases quoted in this article have been likewise, with one exception, in men.

Adults seem also specially liable to this injury; the sixteen patients at the Hôtel-Dieu ranged from seventeen to fifty-three years. Other periods of life are not however exempt; I have treated two such cases in men of sixty-three and seventy respectively, and have seen one in a little girl of five; but in this last case there was probably a separation of the epiphysis.

Boyer has stated that several of the bones are generally involved at once. This is entirely contrary to my own experience; and I would add that of the sixteen cases treated at the Hôtel-Dieu, ten only of which are precisely described, nine were limited to a single bone; in the tenth both the second and the third bone were concerned. It is proper however to draw a distinction between cases of great crushing of the hand, in which commonly several of the bones are broken, and ordinary cases, which are not apt to involve more than one.

Are the five metacarpal bones all equally exposed to fracture? Boyer, Delpech, and Chelius, say that the fifth is the one oftenest broken; Samuel Cooper puts the first in the same rank, while according to M. A. Bérard it is less frequently affected than any other. The question is difficult of solution, in view of the small number of cases. Of the nine single fractures at the Hôtel-Dieu, the first bone of the row was the one concerned in five, the second in two, the third in one, and the fifth also in one. I have myself, however, three times seen fracture of the fourth. The two specimens represented in *Figs.* 60 and 61 belong respectively to the second and third bones.

These fractures may result from either direct or indirect violence.

The direct causes are in the first place all such as give rise to the severe injuries of the hand just alluded to; but many simple and uncomplicated fractures may also be produced in the same way, and the study of these causes is not without interest. Sometimes a foreign body strikes against the bone. Dupuytren related in his lectures the case of a student, who in assisting to let off some fireworks was struck on the hand by the stick of a rocket, and had one of the metacarpal bones broken. Sometimes there is direct pressure on the bone; as in a man whose hand was caught between a wall and a carriage-pole, and pulled it away with fracture of the second and third metacarpals. More commonly it is the hand which strikes against something; as in a woman seen by Murat, who had broken her fifth metacarpal by a fall on the ulnar side of the hand; and in a carter in whom M. J. Cloquet observed a fracture of the fourth and fifth, caused by striking a back-handed blow upon his horse's head. Lastly, there is sometimes a double impulse, the hand moving in one direction and the external object in the other, as when the hand receives the jar of the end of a stick with which one strikes violently against the ground or some other resisting surface; Sanson claims to have seen several such cases.*

Such are the direct causes, acting sometimes on a single bone, sometimes upon several at once. The indirect causes hardly ever affect more than one bone at a time; and they seem to act chiefly upon the third, on account of its being longer than the rest. They present also some varieties. Most commonly the injury is the result of a fall, the fist being closed, upon the prominent head of the bone; such a case is recorded in the *Dictionnaire des Sciences Médicales;* M. J. Cloquet and M. Sabatier† each saw a similar one; in all three the fracture was at the middle of the third bone. Much more rarely, the bone is broken by a fall on the end of the extended middle-finger; Lonsdale cites a case of the kind. In other instances the cause is a violent blow with the fist, planted by the patient, the hand being supinated and the head of the bone striking first; Lonsdale saw such a case; the mechanism is the same as in falls, the bone being between two forces which tend to bring together its two extremities, and giving way in the middle. The mechanism was quite different in the unique case reported by Velpeau; here a water-carrier had had his fore and middle fingers pulled upon by a carter with such force as to break the third metacarpal bone. Lastly, Dupuytren mentions an instance which so far stands alone, in contrast to all those cases in which the bone tends to flex forward, thus almost necessarily giving rise to an angle at the back of the hand;

* See the article headed *Métacarpe, (fractures,)* in the *Dictionnaire des Sciences Médicales;* and that headed *Main, (fractures,)* by M. A. Bérard, in the *Dict. de Médecine* en 30 vols.

† *Journal Complémentaire,* tome xl, p. 188.

here the fracture was caused by the bone being forcibly bent backward. Two men were trying which could pull back the other's wrist; their fingers were interlocked, the heads of the metacarpal bones directly opposed to one another, and the phalanges bent back and pressing firmly against the dorsum of the hand; the stronger of the two broke his adversary's third metacarpal bone.

But are none of the other bones of the metacarpus ever exposed to indirect fracture? We cannot say so theoretically, and for my own part I have seen three cases, involving, what is perhaps remarkable, the fourth bone in each instance. In two of these cases the patients had fallen on the closed hand, and consequently on the head of the fourth metacarpal bone; in the remaining one the cause was somewhat different. A cooper was unloading a cask of wine on the wharf at Bercy; on account of the cold he had a glove on his right hand. This glove was caught by the sharp end of one of the hoops, and the cask rolling on, his hand was caught for a moment in supination, in such a way that the head of the fourth metacarpal bone bore against the edge of a curbstone, while the cask went over the back of his thumb. The bone gave way in its upper third, owing to the forcible bending, the fragments forming an angle salient backward.*

These fractures may be serrated, oblique, or splintered. The obliquity may probably assume any direction; but I have hitherto met with it only downward and forward.

Quite commonly there is no displacement, at least none that is appreciable, especially in fractures caused by direct violence; *Fig.* 61 represents a very oblique fracture which has however united with a hardly perceptible deformity. The diagnosis is in such cases not without some obscurity; the local pain, the swelling, and the impaired motion of the corresponding fingers would accompany a mere contusion, if it were severe; and sometimes even these phenomena are at first very slight in degree; my patient, the cooper before mentioned, kept at work for nearly a quarter of an hour after his accident, and another of my patients apprehended no serious lesion until the next day, when he resumed his occupation. These facts, as well as the so frequent non-detection of the fracture, are amply explained by the position of the bone, sustained as it is by the neighboring bones as by splints. There are but two symptoms by which to recognise it; crepitation and mobility. We may elicit crepitation by forcibly flexing and extending the finger, while we fix the upper part of the bone with the fingers of our other hand; or perhaps by making torsion of the finger from side to side. As to the mobility, the best way of detecting it consists in strongly flexing the finger,

* For a similar fracture by counter-stroke of the fourth metacarpal near its upper end, see the *Gazette des Hôpitaux*, 1833, p. 75.

while with the thumb pressure is made into the palm of the hand, opposite the supposed seat of fracture, so as to get an angle salient posteriorly; but this attempt must be made with care, lest we give rise to a considerable displacement, and then have trouble in correcting it.

The displacements are of various kinds. Albucasis, who was the first to treat at any length of these fractures, admits two very different varieties of them; one in which the fragments are driven in toward the palm, while in the other they form an angle on the dorsal surface of the hand. I have never seen displacement of the former kind; but we may conceive of its occurring, as for instance in the patient whose injury was due to pressure by his antagonist's fingers against the back of the metacarpus. It would seem to have been observed also by M. Lisfranc, in a man with an old fracture of the second metacarpal bone, who is said by him to have had a very considerable deformity in the palm, owing to consolidation of the fragments in an improper position.*

But angular displacement backward is much more common, and occurs in the majority of fractures resulting from indirect violence. It is important to have a correct idea of the nature of this displacement, which is not so simple as might be supposed. In the first place, although the angle would seem to be formed by the projection of both fragments, and especially when we try to press the head of the bone backward, we need only to examine carefully the parts when at rest, to discover that the upper fragment takes no part in it; that this portion of the bone is kept nearly in its normal position by its ligamentous attachments to the carpus, and that, if displaced at all, it would rather incline somewhat toward the palm. It is the lower fragment which rides up backward over the other, while its phalangeal extremity is drawn strongly forward; whence there is a more or less marked projection on the back of the hand, due to this fragment alone, as it is tilted up over the other; whence also there is a depression of the head of the bone, which is no longer on the same level posteriorly with those of the adjoining bones; whence, lastly, and what is the most serious of all these complications, a notable shortening of the bone, due at once to actual overlapping and to angular displacement. All this is remarkably well seen in *Fig.* 60, which represents, as has been said, the second metacarpal; but besides the displacements there shown, there is another which could not be sufficiently brought out in any drawing; the head of the bone had been drawn in toward that of the third metacarpal, and at the same time forward, so that the angle between the two fragments was chiefly salient backward, but somewhat outward also.

Fractures of the metacarpus, when uncomplicated, unite in twenty-five or thirty days.

* *Gazette Médicale*, 1832, p. 29.

The treatment is very simple when there is no displacement. Hippocrates applied nothing but compresses and a bandage; and in fact the neighboring bones serve the purpose of splints. But it is otherwise when there is any prominence or overlapping.

Albucasis varied the position maintained, and the apparatus, according to the direction of the prominence. Thus when the fragments were driven toward the palm, he put into the hand a linen pad over which the fingers were flexed, surrounding the whole with a bandage, and putting a splint of soft leather on the palmar side. When on the contrary the prominence was at the back of the hand, he kept the hand and fingers extended, and applied both a dorsal and a palmar splint.

Guillaume de Salicet adopted extension in all cases; A. Paré, however, allowed only the flexed position; and modern surgeons have been divided in opinion as to which was right. In our own day, Sir A. Cooper and Lonsdale advocate merely keeping the fingers flexed over a large pad filling the palm, and confining them with a bandage, without any splint. But on the other hand, extension seems to count more numerous partisans. B. Bell recommends a palmar splint reaching from the elbow to the ends of the fingers; Delpech was content to place the hand alone upon a board, to which Chelius added a dorsal splint made of pasteboard. Boyer advises the application, over the fractured bone, of two small splints of the length of the hand, and that the roller, after covering the hand, should be carried down over three fingers merely, the one corresponding to the fracture and the two adjoining ones, which latter are to act as lateral splints.

All these forms of apparatus, it must be confessed, are very meagre in their conception. It is of no more use to confine the forearm, as Bell did, than to fasten up the fingers as Boyer did. Sir A. Cooper's pad, modelled upon that of Hippocrates, only suits when there is no displacement; indeed, since the time of Albucasis, the necessity of trying to overcome this latter seems to have been lost sight of. I know of but two recent contrivances which are exempt from this defect, viz., that of M. Lisfranc and that of M. Sabatier.

M. Lisfranc starts with the idea that from the inequality of the transverse and antero-posterior diameters of the hand, a roller exerts much more pressure in the former than in the latter direction. In order to distribute the pressure more equably, he at first contrived a sort of vice, whose branches were to be applied one on the back and the other in the palm of the hand, and then approximated by means of a screw. Afterwards, abandoning this as too complicated, he merely placed over each of the interosseous spaces corresponding to the injured bone graduated compresses and splints, both in front and behind; thus increasing the thickness of the hand so as to make

the bandage press more upon the dorsum and palm than upon the edges.*

It is undoubtedly useful to avoid too great lateral pressure, when it is the second or fifth bone of the row which is involved; but there is no such indication with regard to the intermediate bones, which are completely protected by their position, and for which in all cases a simple pasteboard or wooden splint of the width of the hand will suffice. The apparatus seems to fulfil another indication, namely, the more certain compression of the prominence of the fragments backward or forward; but since this pressure is the same both ways, its effect really amounts to nothing. And besides, it is not enough to press on the angle of the two fragments, to make it disappear, but the head of the bone must be sustained and carried back, or else it will be merely pushed upon, without the angle being effaced.

To carry out this idea, I at first placed over the palmar face of the head of the bone a thick compress supported by a longitudinal splint, in order as much as possible to push up this head above the level of the others; while by means of thick compresses and another splint I exerted strong pressure upon the angle. In this way I succeeded in somewhat diminishing the prominence, but not in entirely effacing it, although the pressure of the dorsal splint was in one case so great as to cause excoriation. I therefore modified my apparatus, making pressure on the compresses by means of two wide transverse splints, one dorsal and the other palmar, strongly approximated with strips of diachylon or lead-plaster; and with this I obtained the most satisfactory results.†

But we must avoid any mistake; the obliteration of the angle only partially remedies the deformity, since the overlapping still remains. M. Sabatier is so far the only surgeon who has sought to overcome this by making permanent extension.

His patient had a fracture of the third metacarpal bone, with shortening of the middle finger by at least half an inch. Extension being duly made, the surgeon fastened the middle to the ring-finger with strips of diachylon, so as to keep it stretched and prevent its yielding to the contraction of the muscles. A padded splint was placed on the palmar face of the hand; graduated compresses were applied over the dorsal interosseous spaces, and the whole was confined by a roller embracing also the index-finger.

Although charpie had been put between the fingers thus fastened together, to prevent too great pressure, the pain occasioned by this apparatus was so severe that it had to be removed on the third day. Fresh charpie was placed between the fingers, and the patient this time went comfortably until the thirtieth day. The callus was then

* *Gazette Médicale, loc. cit.;* and *Clinique Chir. de la Pitié,* tome i, p. 111.

† Lamaëstre, *Mém. sur les fract. des os métacarpiens; Journal de Chirurgie,* Oct., 1846.

formed, but the finger was shortened by three lines; and the articulations of the fingers thus stretched were a good deal stiffened, making douches, etc., necessary. The middle finger recovered its functions very well; but the ring-finger, at the time when the case was published, was still liable to occasional slight pains.

I must confess that this result seems to me too partial and too dearly bought to induce me to imitate M. Sabatier's course, and that I regard it as an important point in treating this fracture to leave the fingers flexed and their joints free. A slight shortening of a finger makes no sensible difference in its use; but we see how important it is that the surgeon should be aware of all the difficulties in the treatment, so as to give a confident prognosis.

Sir A. Cooper has said something of a *fracture of the head of a metacarpal bone*, in which the head is displaced toward the palm, and which might be mistaken for luxation of the first phalanx downward. I know that such a fracture of the metacarpal of the thumb has been considered as a luxation by a careless *interne;* but the true nature of the injury was soon detected. This fracture in my opinion would be more correctly called fracture of the *neck of the bone*, and in young subjects it is probably a separation of the epiphysis. I have seen one case of it in a woman of twenty-two, who stated that she had sustained it when five years old. The lesion had not been understood; no union had taken place; the head of the bone seemed deformed and movable, and presented a concave lateral surface. When the patient flexed her fingers, the head of the bone sank in toward the palm of the hand; the upper fragment projected strongly backward, contrary to what is observed in fractures occurring higher up; and this prominence was so marked that the extensor tendon played not over it, but alongside of it, next to the middle finger. In the extended position of the fingers, the prominence grew less, without entirely disappearing; and then the flexor tendon might be felt on the palmar surface opposite the head of the bone, thickened, expanded, and apparently containing a cartilaginous or bony deposit. Otherwise, all the movements seemed to have their usual extent and freedom.

This fracture is always readily distinguished from luxation, in the first place by the crepitation, and again by the different level of the dorsal prominence. In luxation it is the head of the bone which projects, and it is upon the same level as its neighbors; in fracture the prominence is higher up, and a very marked depression exists between the heads of the two adjoining bones.

Sir A. Cooper recommends treating this fracture by keeping the fingers bent over a pad placed in the palm of the hand; but this is altogether insufficient. In a case of the kind I used my new apparatus, mentioned above, with complete success; only in place of compresses I had to put in the palm a roller of suitable size, in order to bear up the lower fragment.

§ III.—*Fractures of the Phalanges.*

These fractures are not very rare; there are forty-two among our list derived from the Hôtel-Dieu. Like the preceding, they are especially common among men; of these forty-two cases, five only were in women. Lastly, they occur chiefly to adults; a fact which is explained by the character of their causes.

Generally but one finger is concerned; in only five of our forty-two were two or more involved. In nineteen mention is made of the particular finger affected; of these the thumb, middle finger and ring-finger each lay claim to five; the index and little fingers each to two. Finally, of ten cases in which the seat of fracture is still more precisely defined, the first phalanges were affected seven times, the second once, and the third twice. These figures comprehend all varieties, simple or complicated; according to Lonsdale, the former are most commonly met with in the first row of phalanges, and oftener in the forefinger than in any other.

The direct causes are beyond comparison the most frequent. In general the bone is crushed, the fingers being caught between a resisting surface and a body falling from a height or brought down upon them with violence. I have seen a good many such cases from masses of stone falling in the quarries around Bicêtre; they are not uncommon in workmen who use hammers, from their accidentally striking their fingers. Boyer states that when the workmen at the mint had to push each coin under the die with the two first fingers, it often happened that the last phalanx was caught and crushed by the fall of the beam.

It may easily be seen why the integuments rarely escape injury; but the fracture is sometimes simple. A shoemaker had a large stone in his hand, when he received a blow from another stone over the second phalanx of the middle finger, which was broken.* In this case the bone was caught between two resisting bodies; simple fracture more commonly results from a severe blow sustained by the finger, without the latter resting against anything. Of this Lonsdale gives two instances. A child ten years old was playing with his comrades, when one of them threw a stone which struck him on the index finger, his hand being extended; the first phalanx was fractured, the integuments however remaining intact. So also a woman, trying to separate two men who were fighting, received a blow with a stick on the index finger, the first phalanx of which was broken. Ravaton had before given a still more remarkable case. Two soldiers had the ends of their thumbs applied over the touch-hole of a cannon, while the cartridge was rammed down; the charge

* Delamotte, *Traité de Chirurgie*, obs 359.

went off prematurely, and a violent explosion occurred at the touch-hole, fracturing both phalanges of the thumb of one of the soldiers.*

Fractures by indirect violence are very rare, by reason of the smallness and mobility of the phalanges; and I can quote only two such cases. In the first, observed by Delamotte, a man broke the second phalanx of his forefinger in giving a blow with his fist;† the other is related by Lonsdale, of a boy of seventeen, who in a fall caught his thumb between two iron bars, and at the instant felt something crack. Looking at his thumb, he perceived a deformity which he took to be a dislocation; it was a fracture at the middle of the first phalanx.

These fractures are recognised mainly by the mobility and crepitation attending them; there is very little displacement, which is due almost entirely to the fracturing cause, and is either very trifling, or easy to correct. But it sometimes exists as the result of muscular contraction. Boyer has remarked that the flexor tendons draw the lower fragment toward them. To this there may be added actual overlapping, and even slight lateral inclination of the broken pieces. I have seen this triple displacement in an embosser, who had broken with his hammer the first phalanx of the ring-finger, near its metacarpal end. The lower fragment overrode the dorsal face of the upper, upon which it made a prominence; whence its anterior extremity inclined toward its palmar face, and the finger was shorter than the corresponding one on the other hand by more than one-third of an inch. By extension the finger was restored to its normal length; but the overlapping recurred immediately; the contusion and laceration of the integuments forbade any strong pressure being made upon the phalanx. The only result of the treatment was to correct the too great inclination forward of the lower fragment; but the finger was slightly bent toward the middle line of the hand.

These displacements are seen to be similar to those met with in fractures of the metacarpus; it may be added that the treatment presents the same difficulties.

When there is no displacement, we have only to keep the finger at rest for the space of three or four weeks. Celsus advises that it should be fixed to a small splint, *ad unum surculum;* Paulus Ægineta began by applying a roller, after which, if the thumb were concerned, he confined it to the rest of the hand; if the fore or little finger, to the adjoining one; if the middle or ring-finger, to those on each side of it, or sometimes he confined all the fingers together, in order better to secure their immobility, and to make them act as mutual splints.

Ambrose Paré approves of this course; but he expressly recom-

* Ravaton, *Le Chirurgien d'armée*, p. 319.
† Delamotte, *op. cit.*, obs. 358.

mends keeping the fingers "*en figure moyenne, à savoir n'estant du tout ployés ny dressés; pourceque s'ils demeuroient autrement, le callus qui se feroit depraveroit l'action de la main qui est de prendre, ou bien l'aboliroit du tout.*" * This view was adopted in France down to the nineteenth century; only some surgeons supported the fracture with one or two small pasteboard splints. But in Germany and England, extension received the preference; thus B. Bell fixed the broken finger by means of pieces of pasteboard, softened in water and exactly fitted to the shape of the part, doubtless in the form of a trough; after which he secured all the fingers, extended upon a sort of hand-splint of pasteboard or of thin wood. In the thumb only, on account of its isolation and peculiar shape, he advised putting the wooden splint on the dorsal face, making it reach from the base of the metacarpal bone to the end of the last phalanx; to this he added a splint of pasteboard softened in boiling water, so as to take the shape of the palmar surface and ball of the thumb; and finally, a triangular pad was put into the angle formed between the thumb and forefinger, to serve likewise as a support on this side.

In France, Boyer advocated extension, which he made by means of two splints, one dorsal and the other palmar, at the same time fastening the finger also to its neighbors. M. Velpeau applies also the dextrinated bandage in the extended position.

It will be well first of all to note an inconvenience pointed out by Lonsdale, and belonging to all contrivances for permanent extension. If, for example, we have to deal with a fracture of the first phalanx, and apply a splint passing up into the palm of the hand, the head of the metacarpal bone will project against this splint more than that of the phalanx will, whence there will be left between the latter and the splint a slight space, more marked in the case of the fore and middle fingers than in the other two. I admit that this interspace amounts to almost nothing in hands with supple joints, and the fingers of which can be perfectly extended without difficulty; but in workmen, whose callous skin permits only partial extension, it is apt to be very considerable. Unless, then, we are very careful, the bandage surrounding the broken phalanx will force in the two fragments toward the splint, making them present an angle forward; Lonsdale has figured a deformity of this kind, observed in a man who two years before had sustained a fracture of the index-finger by the fall of a heavy spar; and to guard against such a result, he recommends placing between the finger and the splint a pad just filling up the interspace.

But extension itself gives rise to one serious inconvenience, namely, a stiffening of the joints, sometimes even more troublesome than

* ["In a medium position, that is, not entirely bent up, nor quite straight; lest if they be kept otherwise, the callus formed should impair or entirely abolish the grasping power of the hand."]

the fracture. Hence B. Bell advises the removal of the apparatus on the tenth or twelfth day, in order to make passive motion, which should thenceforward be repeated daily. This would, however, be in fact an excess of caution; it suffices to move the joints three or four times in the course of the consolidation. But we should do well at least in avoiding one of the chief causes of the stiffening,—the extension,—and to return to Ambrose Paré's plan of semiflexion.

For my own part, I arrange on the palmar face of the finger a small oblong compress, then a splint of firm pasteboard reaching up merely to the hollow of the hand, with a slight bend so as to fit the finger in the middle position; one or two strips of lead-plaster, fastening the finger to the splint, complete the apparatus. We may also, if we think proper, fasten the injured finger to its sound neighbors; but it must be borne in mind that the spaces between the fingers increase as we go farther from the metacarpus, and hence that by approximating too much the last phalanges, we run the risk of causing lateral displacement at the seat of fracture; which actually took place in the patient just alluded to.

When there is overlapping, if the integuments are uninjured, we have merely to reduce the fragments and press them against one another, to correct it. M. Baudens, in a case of comminution, tried a different plan; he placed the hand on a board-splint, with bands fixed by one end to the ends of the fingers and by the other to the board, so as to make, in fact, permanent extension. This traction did not prevent some shortening of the fingers.*

The complication of a simple wound is in these cases but trifling; Hippocrates remarks that the fracture may be reduced without danger, even when one fragment projects through the skin, and that the cure may be quite readily accomplished. But it is different when the soft parts are bruised and the bone crushed, and the question is between immediate amputation and an attempt to save the part. Boyer advises amputation when the last phalanx is the one concerned, temporising if it is one of the others. I have tried to preserve a good many such fingers, but in most cases without success. Still, as we sometimes obtain good results, we must not be too hasty; for although, when from the amount of destruction a cure seems impossible, immediate amputation saves the patient time as well as unnecessary pain, yet, small ground for hope as there may be, we should remember with Boyer that it is always time enough to amputate when the necessity for doing so is clearly demonstrated.

* *Gazette des Hôpitaux*, 1846, p. 193.

CHAPTER XV.

FRACTURES OF THE PELVIS.

These are generally treated of after those of the thorax or of the spinal column, so as to complete the subject of fractures of the trunk. But just as I preferred placing fractures of the sternum next to those of the clavicle, I have thought proper to connect those of the pelvis with those of the thigh, because besides their proximity anatomically, several of them present remarkable analogies to one another, either in their symptoms or in their indications.

Fractures of the pelvis are very rare, since in eleven years there occurred but ten at the Hôtel-Dieu. Although generally the result of direct violence, such as falls on the pelvis or excessive pressure, we shall have to notice that some of them are caused by falls on the feet. They are quite frequently complicated with contusion or laceration of the pelvic viscera, by which the patient's life is endangered much more than by the mere injury of the bone; sometimes, however, this latter may cause death, by the formation of an abscess around it.

These cases present numerous varieties, which however are almost always mixed up together in describing them. In order to give more precision and clearness to our study, I shall describe first the fractures proper to each division of the pelvic bones, the sacrum, coccyx, ilium or crista ilii, pubis and ischium; then such as, affecting the entire pelvis, present special phenomena of importance, and which I shall call *double vertical fractures of the pelvis;* and finally, I shall say a few words concerning fractures in the cotyloid cavity.

I might have added another section, on comminuted fractures of the pelvis, in which it is separated into three, four, six, eight, or more pieces; but besides that they consist merely in combinations of the fractures already enumerated, their treatment should be very much the same, supposing that we can recognise them and institute a treatment. Multiple fractures of the pelvis are apt not to be wholly recognised, both from the absence of displacement and often also from the obscurity of the crepitation; Dr. Lyon, of Glasgow, has even published a case in which seven or eight fractures were dis-

covered by dissection, although no crepitation had been perceptible during life, from any movement whatever of the pelvis.*

[I have seen a case in which a fracture of the horizontal ramus of the pubis on each side, of the ascending ramus of the ischium on each side, and of the sacrum vertically with much comminution at its lower extremity, with partial separation of the right sacro-iliac symphysis, entirely escaped detection during life. The left leg was also fractured, and the urethra was ruptured across; the patient's death was brought on in a day or two from the last-named injury.]

The majority of such cases are untreated also, the internal injury causing death sooner or later.

§ I.—*Fractures of the Sacrum.*

This fracture is extremely rare; it occurred only once among the 2358 patients at the Hôtel-Dieu. It would seem, however, that it was known to the ancients; and Paulus Ægineta gives rules for its treatment, whether simple or compound. After this we find no new mention of it until the sixteenth century. Ambrose Paré says that he has several times seen the sacrum fractured *by balls or other crushing forces*, and the patients recover; but if the spine be involved, says he, *death is almost inevitable.* This distinction in the prognosis has no foundation either in theory or in practice.

The sacrum presents in its fractures two varieties; one which is limited to that bone, the other which extends to the other pelvic bones.

Simple fracture always results from a fall on the lower part of the sacrum; but the bone sometimes strikes full upon the ground or upon some resisting body, and sometimes by one side merely; hence arise quite notable differences in the symptoms.

I have been able to collect but three observations of fractures caused by the former mechanism;† in all the sacrum was divided transversely; and so also it had been in the two long-standing cases figured by Sandifort. The seat of the fracture varies considerably. In one case reported by M. Judes, the upper portion of the bone is said to have been affected. I doubt, however, whether fracture is met with above the lower border of the sacro-iliac junction, and generally it involves only the lower half of the bone. In one of Sandifort's drawings, the callus presents an ossified edge a little below the third sacral foramen; the other drawing represents a bone with six pieces, and the fracture at about the fourth foramen. M. J. Cloquet

* *Archiv. Gén. de Médecine*, 1845, tome vii, p. 237.

† Malgaigne, *Mémoire sur les fract. du sacrum et du coccyx; Journal de Chirurgie*, June, 1846.

has seen it at the lower third, and M. Bermond quite low down, near the articulation with the coccyx.

There is one sort of displacement which is almost constant, in which the lower fragment, retained in contact with the other by its base, has its apex inclined forward. In Sandifort's two specimens, the displacement was such that the two fragments seemed fused to each other at a right angle; in a preparation bearing the name of Richerand, in the Musée Dupuytren (No. 12,) the apex of the lower fragment is in the same manner carried forward with the coccyx, and the great sacro-sciatic ligaments are drawn in the same direction, so as to form a curve convex anteriorly. I know of but two cases resulting from a lateral blow; Fleury de Clermont published one, and I observed the other myself, quite recently. In Fleury's patient the fracture was transverse, and seated between the second pair of anterior sacral foramina; there was no inclination forward of the coccygeal fragment, but the apex of the bone was displaced laterally, evidently as the result of the direction of the external violence. In my own patient, two incomplete and nearly transverse fractures divided the sacrum opposite the third and fourth pair of foramina, and allowed of the bending of the lower fragment somewhat forward; but the principal fracture, running obliquely downward and inward, began at the edge on the right side on a level with the third sacral foramen, and passed down parallel with the edge as far as the coccyx; thus detaching a longitudinal fragment one-quarter to one-third of an inch wide, which was drawn over toward the right. There was also an oblique fracture of the coccyx.

The first symptoms of this fracture are the pain and contusion, which are always quite severe. In Fleury's case the pain was referred rather to the buttock, where the shock had been received, than to the actual point of injury; it was increased by standing up, and still more by flexing the body forward. In my patient the pain was complained of both at the part struck and at the fracture; it was increased by pressure, and extremely aggravated by any attempt at coughing.

Sometimes these are the only signs of the fracture; but most commonly, in exploring the sacral region, we are struck by the angle formed by the two fragments, which is more or less salient posteriorly. By bearing upon the apex of the sacrum the prominence of this angle is increased, as is also the pain. The finger passed into the rectum finds the point of the coccyx projecting forward more than usual, but easily pushed back; by which movement the pain at the seat of fracture is increased, but the angle formed there is diminished or even obliterated. Carrying the finger higher up, we come to a transverse depression, or rather to an entering angle corresponding to the salient one posteriorly. At the same time we ascertain whether or not there is any lateral inclination of the coccyx.

Lastly, the different movements communicated to the lower fragment give rise at times to more or less distinct crepitations.

But the coccyx may be carried forward so far as to obstruct the anus; which was so markedly the case in M. Bermond's patient, that he could not pass his finger into her rectum without first inserting a female catheter. The pain was excessive, but was assuaged by the presence of the finger in the rectum, which brought the fragments together; when this was removed, the patient cried out loudly to have it replaced for her relief.

With the signs just pointed out, it would be difficult to misapprehend such an injury. But its excessive rarity becomes a fruitful source of error, by directing the attention of the surgeon toward other lesions; thus in Fleury's case the pain was combated by means of leeches and poultices, and the fracture remained undiscovered until revealed by dissection. M. Judes admits that his diagnosis was made accidentally; he had passed his finger into the rectum to ascertain the state of the gut, and was very much surprised at perceiving bony crepitation. Lastly, after the detection of the fracture we may err as to its direction and seat; the autopsy alone revealed to me the longitudinal fracture which existed in my patient.

Fractures of the sacrum unite very well when they are simple; but the severity of the external violence may give rise to serious complications. Fleury's patient died on the twenty-fifth day, from the development of an abscess in the neighborhood of the fracture. Mine succumbed at the end of a month, having among other sequelæ a gangrenous abscess laying bare the sacrum.

Reduction is easy, the finger being introduced into the rectum, as advised by Paulus Ægineta; the difficulty is to maintain it. M. J. Cloquet merely kept his patient lying on his side, a position less painful to him than any other. A mere inclination of the coccyx somewhat forward or outward is not likely to involve any very grave inconvenience; but when this projection gives rise to painful pressure upon the rectum, it becomes necessary to correct it.

M. Judes first conceived the idea of substituting for the finger some permanent contrivance. He placed in the rectum a wooden cylinder five inches in length by three in circumference, supporting it by graduated compresses and a T bandage. Every three days this apparatus was removed, and an enema given. After forty-five days the patient was able to leave his bed, and soon resumed his occupation without pain or inconvenience.

M. Bermond sought to gain the same end by different means. He at first tried the tampon; a square of linen, spread with cerate, was pushed by its middle into the rectum, and the sac thus formed by it was stuffed with charpie; afterwards its angles were drawn out a little, and a second tampon formed of them, to hinder the displacement of the first. The patient felt some relief; but during the night her

abdomen became distended, and next day it was necessary to unstop the rectum to give passage to a copious dejection of gas and of fecal matter. There was needed, therefore, a tampon which should allow any gaseous matters to escape. This M. Bermond made with a silver canula five inches long and eight and a half inches wide, and a bag so fitted on it as when stuffed to form the inner and outer tampon; at the outer end of the canula were two rings, from which two bands passed to a body-bandage, so that the whole apparatus could be drawn backward or forward at will; and lastly, a cork was put in to prevent the discharges from being constant.

The patient was thus dressed on the third day; she was kept in bed, sometimes on her face, sometimes on her back; it is curious that in her the lateral decubitus was the most painful. While she was lying on her back, care was taken to arrange cushions under her thighs, so as to prevent any pressure of the sacrum upon the mattress.

This apparatus caused at first a sensation of weight and bearing down, which disappeared in a day or two. It was kept in for seven days, and then removed; the lower fragment was found still movable, although the coccyx kept its place better. The margin of the anus was red, swollen, and even slightly excoriated; but M. Bermond thought proper to re-introduce the canula, diminishing, however, the quantity of charpie around it.

It was taken out for the second time twelve days afterwards; the lower fragment was no longer movable, all the motion which took place seeming to be in the sacro-coccygeal articulation. After this it appeared unnecessary to re-apply the apparatus; the slight inflammation around the anus soon subsided, and in five days after the removal of the canula the patient could move about and sit down without inconvenience; she soon resumed her customary occupations.

So much for isolated fractures of the sacrum; those which are combined with other fractures of the pelvis result from very various causes, and are themselves as varied. Sometimes a man is caught between a wheel and a post; more commonly the wheel passes over the pelvis and crushes it. In a case of this kind, Lacaze Perouï found four fractures of the sacrum, two transverse, and two dividing the lower fragment into three pieces. M. Guérétin has seen the bone broken crucially, that is to say, besides a transverse fracture each fragment was in its turn divided by a vertical one. The fracture may be entirely simple and transverse, as in Richerand's specimen in the Musée Dupuytren, before alluded to. All these patients succumbed; it is to be supposed that the gravity of any case depends on the number of fractures, and on the amount of visceral injury.

Lastly, Richerand has published the much more curious case of a vertical fracture of the sacrum, discovered at the autopsy on a man who had jumped from the second story of a house, lighting on his

left foot. But I shall refer to this case again in connection with double vertical fractures of the pelvis.

§ II.—*Fractures of the Coccyx.*

These have only taken a place among fractures through the mistake of a translator of Paulus Ægineta, by which remarks expressly referring to the sacrum are made to apply to the coccyx. They are extremely rare; I have for my own part seen but one, which was joined with a fracture of the sacrum, and was only detected at the autopsy; as to cases in which it exists alone, our positive knowledge of them reduces itself to the following passage from M. J. Cloquet.

"In old persons," says he, "when the different coccygeal bones are fused together and with the sacrum, the coccyx may be broken by a fall upon the buttocks, or by a kick in that region, as I have myself observed to happen in one instance."

This example is so far the only one with which I am acquainted, and it is to be regretted that it is so alluded to without any details. M. J. Cloquet indeed mentions a tiler who fell from a roof, and as he says fractured one thigh, both legs, and the coccyx; the coccyx became carious, and was discharged bit by bit. But he does not appear to have himself made out the fracture; and the caries of the coccyx proves no more here than in the observations of J. L. Petit, quoted in the same article as proof that these fractures may be followed by serious symptoms. Petit alludes to two cases of caries of the coccyx; but I know of no mention which he has anywhere made of fractures of this bone.* I shall again refer to this question in speaking of luxations of the coccyx.

§ III.—*Fractures of the Crista Ilii.*

Under this head come all those fractures which traverse the iliac fossa, or the ilium properly so called, so as to separate from the bone a portion or the whole of the iliac crest. Duverney was the first to speak of it under the name of *transverse fracture of the iliac bones;* but when it is very close to the crest of the bone, it has seemed to me rather to affect a curved line concave superiorly, starting commonly at a certain triangular enlargement of the crest, overlooked by anatomists, and thence running sometimes forward and sometimes backward; sometimes even assuming both directions at once, when it constitutes a double fracture dividing the crest into two fragments.

The causes of it are always direct; a fall from a height upon the

* J. Cloquet, art. *Bassin,* in the *Dict. de Méd.* en 30 vols.; J. L. Petit, *Œuvres Posthumes,* tome ii, p. 205, *et seq.*

side, a heavy blow, powerful pressure, etc. M. Guérétin has seen this fracture produced in an unusual way; a man had fallen a distance of about twelve feet; he alighted standing, but as he alighted the upper portion of the thigh and the iliac crest rubbed violently against a post, and hence there resulted a fracture of the anterior half of the crista ilii.*

The symptoms are at first severe pain, and greater or less contusion from the external violence. The patient cannot walk at all, or if he can it is only with difficulty, from injury of the muscles going from the crest to the femur. In one case observed by Duverney, the psoas and iliacus were torn across. Sometimes there is no displacement; this occurs chiefly when the fracture is situated very far from the crest; in the case cited by Duverney the ilium was broken transversely, and the fragments had remained in position. When the detached portion is very small, it may likewise keep its place, but it is not uncommonly thrown inward. Sanson saw a much more extensive displacement; a painter fell from the top of a ladder, and broke the crista ilii in its middle third; the fragment, which measured at least four fingers'-breadths each way, was drawn up within the substance of the abdominal walls, nearly to the lower boundary of the thorax; it could not be replaced, and the patient recovered with this deformity.

Besides the external contusion, we sometimes meet with lesions of the abdominal viscera, of a more or less severe description; but these are unconnected with the fracture. Like Sanson, Dupuytren noticed that in fractures on the left side the patients are often affected with obstinate constipation, which is with difficulty overcome by enemata. This phenomenon would indicate that the corresponding portion of the colon had been injured; but it is very far from constant.

The diagnosis is often very obscure, especially when by the *embonpoint* of the patient, or by the swelling due to the contusion, the parts are masked. In the contrary case, if perhaps we are not at once struck by the depression of the fragment, we may grasp with our fingers the iliac crest, and by moving it to and fro detect mobility and crepitation. It is well, in order to relax the iliacus muscle, to flex the thigh upon the trunk. Monteggia relates that in an examination of this kind, when the thigh was extended the fragment was immovable, and the fracture could not be detected, while by flexing the limb it was at once revealed by mobility and crepitation. Léveillé says, moreover, that he has known crepitus to be elicited by merely making alternate flexion and extension of the thigh.

The prognosis is favorable unless from injury of the abdominal viscera; yet this complication is either so rare or so trifling, that the majority of these fractures terminate in recovery. Monteggia cites

* *Presse Médicale*, p. 43.

two fortunate cases, Sir A. Cooper two others; the patient mentioned by M. Guérétin was cured in twenty-two days; Lonsdale saw a fracture of this kind cured by the end of a month, in spite of a large slough in the groin; a patient treated by M. Godelier, although thrown back by several symptoms due to the violence of his fall, walked well on the seventy-fourth day;* and I have myself treated two cases which recovered very rapidly and very well. To tell the truth, I know of but one instance which terminated fatally; it is given by Duverney, in which extensive suppuration, filling the whole pelvis, carried the patient off on the fourteenth day.

The treatment amounts to very little. To reduce the displaced fragment, it is recommended to grasp it with the fingers, having the thigh strongly flexed, or even putting it at the same time into flexion and adduction. Layard devised a more ingenious plan; his patient had a transverse fracture, three fingers'-breadths below the crest, the fragment being driven inward; he had the upper part of the belly compressed with a towel by two assistants, while another assistant pressed the belly at the sound side so as to crowd the viscera against the detached fragment, and push it into place; after which he maintained the constriction by the towel, and kept the patient in bed for three weeks. The cure was complete, and the patient walked very well at the end of a month;† but there is reason to doubt whether the apparatus had much to do with the success of the case.

The fragments being reduced as completely as possible, Böttcher advises keeping the thigh flexed; Monteggia, arguing from the case alluded to, prefers that it should be extended. But most authors insist on the application of a body-bandage, not forgetting the use of resolvents.

Resolvents here, as elsewhere, only keep the patient wet and uncomfortable, except when the pain and inflammation call for emollient cataplasms. The bandage is contra-indicated for fractures in which there is a tendency to displacement inward. Discussion as to the proper position are to say the least useless; the patient will soon find out for himself how he lies most easily. M. Godelier laid his patient on the sound side, and he seemed to be comfortable; but some days afterwards he turned insensibly on to his back, and felt much easier for doing so.

On the whole, rest in bed, upon the back unless the patient prefers some other position, is all that is required in these fractures; everything else is useless or hurtful. When there is no notable displacement, some patients can resume their occupations as soon as

* *Recueil de Mém. de Méd., Chir., et Pharm. Militaires*, tome x, p. 266.

† *Philosoph. Trasactions*, 1744–45, vol. xliii, p. 537. This surgeon has been by Monteggia and others called *Boyard*, the mistake having been copied from one to another.

the pain subsides, and long before consolidation is complete; one of mine walked on the ninth day, and would not stay in the hospital after the fifteenth.

An external wound does not here form a very grave complication, provided there is no internal injury. M. Lachèze d'Angers has given a remarkable instance of this. A workman, at the bottom of a quarry, had had the upper and outer part of the right ilium crushed by the fall of a cask; and through the lacerated integuments the bone was felt comminuted into a number of movable splinters. A dozen of these were extracted, the necessary incisions being made; a threatened peritonitis was warded off by bleeding; and at last, after several months of treatment, the patient was entirely cured except a slight halt in his gait.*

§ IV.—*Fractures of the Os Pubis.*

The history of these fractures also is but modern; Duverney reported the first observation in regard to them.

Their causes are commonly either powerful pressure, or the fall of some very heavy body upon the anterior portion of the pelvis. I have, however, seen a fracture of the pubis the result of the patient's jumping from a height of three stories; and since both he and the by-standers affirmed that he alighted first on his feet and then on his buttocks, it would seem difficult not to infer that this fracture was indirect.

Sometimes the fracture is limited to the descending ramus of the pubis, of which a fragment more or less considerable in size is detached; or the body of the bone may be involved, as in the case seen by Duverney, in which it was separated into four pieces; or lastly, it may separate the bone from all its connections, of which very curious lesion several instances have occurred. In my patient above alluded to, who survived his fall only a few hours, I found at the autopsy a double oblique fracture, dividing the descending ramus near the ischium, and the horizontal ramus close to the ilio-pectineal eminence, just grazing by the cotyloid cavity; moreover, the bone had been, as it were, torn away from its incrusting cartilage at the symphysis, which had therefore undergone an actual separation.

Fractures of the pubis may be simple or splintered, and with or without lesion of the integuments; but these are in a manner accessory circumstances. Those which should mainly attract our attention are the displacement of the separated portions, and the injury of the bladder or urethra.

M. Nivet exhibited to the *Société Anatomique* a double fracture of

* *Archiv. Gén. de Médecine*, tome xvii, p. 307.

the ramus, in which the piece detached had been curiously displaced in front of the body of the bone, and had torn the integuments of the fold of the thigh just outside of the labium externum.*

Maret has related a case of fracture of the body of the bone. The fragment seemed carried inward and forward; in fact, catheterism was rendered necessary by retention of the urine, and an obstacle was encountered from a hard body which was felt in the right labium externum. Maret made an incision an inch and a half long in the inner face of the labium, and extracted a very large fragment, which involved nearly all the body of the pubis.†

These cases are the most favorable of all, and perhaps also the rarest. There is far more danger when the detached portions are driven into the pelvic cavity, tearing the urethra or the bladder, or even entering the cavity of the latter. Still, rupture of the bladder is not always to be attributed to its penetration by a fragment; in M. Nivet's patient it was torn through at its junction with its neck, without any apparent communication with the fracture; this was an independent lesion, due entirely to the external violence.

When the fracture is uncomplicated, it of itself involves no danger. Sir A. Cooper says that he saw a successful result in a fracture at the junction of the ischium with the pubis, and in others closer to the pubic symphysis. The existence of an external wound does not add much to the gravity of the case. After the incision made by Maret, and the extraction of the bone, the wound took but twenty days to heal; and notwithstanding the formation of an abscess over the hip, the cure was completed in six weeks. It should be stated, however, that the displacement of the principal fragment, if it comprises nearly the entire pubis, may diminish the circumference of the pelvis when consolidation occurs. Lendrick had an opportunity to dissect the pelvis of a man who had long before been cured of such a fracture; the distance from the pubic symphysis to the anterior inferior iliac spine was lessened by about an inch.‡

But when, besides the division of the bone, there is a rupture of the bladder, death is almost inevitable. M. Nivet's patient survived but twelve days. In another case, reported by M. Boudet, the urethra was torn, and a sound which was introduced found its way into the rectum; the patient lived but a short time.§ Sir A. Cooper, however, relates a case, although not very fully, in which there was diagnosed a rupture of the bladder below the peritoneum; by the use of the catheter, the patient seemed to be doing well. M. Nélaton has communicated to me a much more remarkable case; a woman

* *Bulletins de la Soc. Anatomique*, 1837, p. 194.

† Maret, *Obs. sur les fract. des os du bassin; Mém. de l'Acad. de Dijon*, 1774, tome ii, p. 85.

‡ *Archives Gén. de Médecine*, 1839, tome v, p. 484.

§ *Bull. de la Société Anat.*, 1839, p. 103.

was brought into his wards at Saint-Louis, with her pubis fractured by a carriage-wheel passing over it; a fragment had penetrated through the bladder into the vagina, and was extracted by the orifice of the latter; yet in spite of extravasation of urine, and an abscess resulting from it, M. Nélaton succeeded in accomplishing a cure. What follows is however still more curious; M. Lenoir admitted into La Pitié, some years afterwards, a woman suffering from vesical calculus. She was of the same age with M. Nélaton's patient; she said she had been treated at Saint-Louis for a fracture of the pubis; and M. Lenoir having extracted the stone by the urethra, found its nucleus to consist of a bit of bone. Was this the same patient, or another? The former seems to me the more probable supposition, considering the rarity of cases of this fracture, especially with a favorable termination.

Still, as shown by Sir A. Cooper, ruptures of the bladder below the peritoneum are the only ones susceptible of a cure; such as communicate with the abdominal cavity are necessarily fatal.

The treatment of fractures of the pubis amounts to very little. We should first endeavor as much as possible to replace the fragments. When this cannot be done, if there is an external wound, we should extract through it all such pieces as might prove injurious; but if no such wound exists, we should require very strong reasons to induce us to follow the example of Maret. He himself was not without apprehension lest in his patient, a girl of eighteen, the loss of substance might cause approximation of the hips, some limping perhaps, and above all narrowing of the pelvis. He therefore made her lie upon her back, with the right thigh flexed and at the same time abducted, during the period required for the bone to be reproduced. His attempt was successful; the pelvis preserved its size, the gait remained even and easy, and the girl, being subsequently married, was delivered of her children without any trouble.

§ V.—*Fractures of the Ischium.*

Maret first studied these, in 1765; and I know of but six instances which have hitherto occurred. Sometimes the ischium is separated almost entirely, in front from the descending ramus of the pubis, and posteriorly from the cotyloid cavity, which remains intact; sometimes it is only the tuberosity which is detached from the rest of the bone.

In three cases observed by Maret, Percy, and Rankin, the determining cause was a violent fall upon the buttocks, and without doubt on the tuber ischii.* In another instance, communicated to Sir A.

* See *Maret, op. cit.; Histoire de Percy*, by Laurent, p. 99; Rankin, *Gazette Médicale*, 1833, p. 53.

Cooper by B. Bell, it was the explosion of a mine; in a fourth, related by M. Jobert, the bone was broken by a gunshot wound;* and in the last and most curious of all, a woman, who two years before had had the inferior pelvic strait narrowed by a double vertical fracture, had the ischium broken during artificial delivery;† I shall again refer to this in the succeeding section.

The symptoms vary in different cases, and in the first place according to the height from which the fall may have occurred. The patient mentioned by Maret fell from the top of a walnut-tree; he got up with difficulty, but could not walk. Percy's patient was thrown from a horse; he got up and returned home on foot, supported by two of his comrades. Rankin's fell a distance of thirty feet; the integuments were torn, the testes laid bare, the urethra divided, and the ischium detached from the rest of the pelvis by a double fracture with numerous splinters. In Sir A. Cooper's case the fracture was likewise attended with a wound, and with splintering.

If there is a wound, the finger can be applied to the fracture; but when the integuments are intact, the diagnosis is the more likely to be erroneous from the idea of such a lesion not readily occurring to the surgeon's mind. Maret detected no deformity, and no change in the length of the corresponding limb; but in putting the thigh through certain motions he perceived crepitation, and by placing his hand in the groin and flexing the thigh he noticed a slight mobility, accompanied by the same sound. He judged the seat of the fracture to be above the tuberosity of the ischium, at that part of the bone which goes to form the boundary of the obturator foramen. Percy at first overlooked the fracture, and thought the injury was merely a severe contusion. But on the subsidence of the inflammation, the patient no sooner tried to put his foot to the ground than he felt something crack in the thigh, with a sickening pain. Percy then laid him on his face, and on examination detected a fracture of the tuber ischii. The entire tuberosity was movable under his fingers; and it seemed divided into two portions, as if the incrusting cartilage had been torn from the bone. In M. Papavoine's patient, the lesion was only discovered by dissection.

In all the cases, then, the fragments remained in contact, without any notable displacement. It would however be presumed that the powerful muscles inserted into the tuberosity would draw down the detached portion if its fibrous connections were entirely ruptured; as was actually the case in M. Jobert's patient, in whom the fragments were separated by a space of more than two inches.

With such a separation, the diagnosis could not present any difficulty; and in ordinary cases it could be pretty clearly made out

* See Sir A. Cooper's chapter on *Intra-capsular fractures of the cervix femoris;* and Jobert, *Plaies d'armes à feu*, p. 224.

† Papavoine, *Journal des Progrès*, tome xii, p. 234.

from the crepitation, and especially from the mobility. I would not however vouch for the accuracy of the opinions given by Maret and Percy as to the precise seat of fracture; and I believe it would be important, in order to be satisfied of it, to examine the internal face of the bone, by introducing the finger into the rectum in the male, or into the vagina in the female.

The prognosis would seem not to be very grave; M. Papavoine's patient sank from the effects of her accouchement; the other cases recovered, although three of them presented quite serious complications. Perhaps any great degree of separation should make us apprehend some impairment of the motions of the limb. In M. Jobert's patient, union being accomplished only through a fibrous band two inches in length, the flexion and extension of the thigh were somewhat hindered, especially during the first two months; but *gradually*, adds the observer, *the limb resumed its usual functions, if not entirely, at least beyond the expectations of either the patient or the surgeon.*

In fractures with displacement, hardly any treatment is called for but rest in bed. Maret applied a medicated compress, and a spica bandage to the groin. This was done in reference rather to the contusion than to the fracture; the recovery was rapid and easy. Rankin confined himself to extracting the splinters and dressing the wounds; complete consolidation ensued.

But when there is separation, what is to be done? Percy proposes a wide leather pad stuffed with hair, and having in the middle an opening for the lodgment of the buttocks. One border of this pad, rather thin, should extend beneath the loins, the other, very thick, beneath the thighs; and it was hoped in this way to incase the tuberosities with sufficient solidity to insure their union.

I should not myself expect much from this. Such a pad would seem to me not only useless but hurtful, since the pressure exerted on the fragment or on the muscles attached to it would have the effect of carrying it forward. I think therefore that our best plan is to keep the patient on his back, his pelvis slightly raised, his legs somewhat flexed, and the whole limb immovably confined.

§ VI.—*Double Vertical Fractures of the Pelvis.*

Under this name I shall describe a form of multiple fracture of the pelvis, distinguished from all others by a species of regularity, and meriting besides special attention in the triple aspect of diagnosis, prognosis and treatment. It is a combination of two vertical fractures, separating at one side of the pelvis a middle fragment comprising the hip-joint; according as this fragment is carried upward or inward, the femur follows its movements, and hence result

changes in the length and direction of the limb which have often misled practitioners.

Of these two fractures the anterior is almost constantly seated in the horizontal and descending rami of the pubis, separating this bone from the ilium and ischium; the posterior is always back of the cotyloid cavity, and generally in the ilium; once however it was seen by Richerand in the sacrum. Lastly, instead of a fracture, we may have here a separation of the sacro-iliac symphysis; of which an instance is reported by M. Gerdy.*

The causes are most frequently direct, such as falling from a height upon the hip, crushing of the pelvis between two carriages, a wheel passing over the hip, the kick of a horse, etc. These are exactly such forms of violence as those by which the crista ilii is broken; and we sometimes see this fracture combined with the two others. It is to be presumed however that to fracture the pelvis from top to bottom, the shock should fall lower down and more full, and should bear chiefly upon the great trochanter. Hence arises one point of resemblance between this fracture and that of the cervix femoris; moreover, what is more remarkable, they may either of them be caused by counter-stroke, as in falls on the feet. Richerand's patient was a man aged 53, who fell from a second-story window, alighting directly upon the left foot.

In this last case no one could doubt the indirectness of the cause; but even when the shock would seem to fall most directly there is at least one of the fractures which must be otherwise produced. In the Musée Dupuytren may be seen (No. 11) the os innominatum of a young man who fell from a second story; the pubis is completely fractured through both its horizontal and its descending ramus; but the posterior vertical fracture, which affects the ilium, has involved only the outer table of the bone, the inner table having merely yielded. It is evident that this last fracture is secondary, the external violence first producing the other one and then driving in the iliac fragment. This view of the mechanism of the double fracture will aid in explaining certain displacements which may present themselves in connection with it.

The first phenomena of this fracture are pain, contusion and its consequent swelling, and impairment or loss of motion in the lower extremity. Generally the foot is more or less everted; in Richerand's case, however, this deviation did not occur. Sometimes the middle fragment is movable, with crepitation; the latter sign has also been elicited by pressing from before backward or from behind forward upon the great trochanter, by traction upon the thigh, or by putting it through different movements. But the most positive information is derived from the displacements.

* Richerand, *Nosographie Chirurgicale*, tome iv, *Vices du bassin;* Gerdy, *Archives Gén. de Médecine*, 1834, tome vi, p. 378.

These displacements are of two kinds. That which is at once the most common and the most evident, consists in the carrying up of the middle fragment, which draws with it the lower extremity, giving rise to an apparent shortening of about half an inch; Richerand assured himself in regard to his patient that the anterior superior spine of the broken bone was above the level of that of the other by the distance mentioned. But in a patient whose pelvis had been caught between two carriages, Larrey observed an elongation of the limb of as much as an inch and one-third, which persisted even after consolidation was complete.*

But other displacements quite as serious, and not to be detected except by careful examination, consist in the various inclinations of the middle fragment. I have mentioned how, in the specimen in the Musée Dupuytren, it was driven in by its anterior border, the incompleteness of the other fracture preventing the posterior edge from leaving its place. When both parts of the fracture are complete, it may happen that the anterior border of the middle fragment is depressed into the pelvis, while by a sort of balancing† the posterior border projects outward; such a case seems to have been observed by Larrey. Lastly the middle fragment has been seen driven in at its lower portion, while above it projected outward, the balancing taking place in a direction contrary to that in the preceding case; a form of displacement tending to widen the superior strait of the pelvis and to notably diminish the inferior. All these forms existed at once in a woman whose case is related by M. Papavoine, and who died long after being cured of her fracture, in consequence of the narrowing of the inferior strait.‡

This woman was thirty-four years old, when she received on the right side of the pelvis a kick from a horse, producing two vertical fractures; the anterior one was at its usual place, and the posterior one was seated in the ilium, a little in front of the sacro-iliac symphysis. She was admitted into the Hôpital Saint-Louis, and discharged in four months with a vicious consolidation. The fragment had in the first place risen up a little; it had also undergone a horizontal tilting, by which it projected anteriorly into the pelvis, while behind it was carried outward so as to overlap the posterior fragment by more than an inch, reaching to the upper edge of the sacrum. Another vertical tilting had taken place, carrying the crista ilii outward, and the tuber ischii on the contrary inward, so as to make the transverse diameter of the superior strait amount to five inches and a half, while the inferior only measured two inches and two-thirds. I pass over the other details; these will suffice to explain the sequel of this history.

* *Archiv. Gén. de Médecine*, tome xii, p. 138, and tome xvii, p. 308.

† ["*Bascule*;" the word means a see-saw, like a scale-beam; there is no word in English which exactly answers to it.]

‡ Papavoine, *Journal des Progrès*, tome x, p. 234.

The woman came back to the Hôpital Saint-Louis two years afterwards, pregnant, and near her full term. She had previously had five successful accouchements, but this one was terrible; she was only delivered at the fourth day, by means of the forceps, and after such violent tractions that, to say nothing of other extremely grave injuries, she had a fracture of the ischium on the right side. Death ensued at the end of two days.

The diagnosis is quite easy when we can readily feel the middle fragment moving under our fingers; otherwise the rarity of the fracture may put us off the right track; and hence mistakes in diagnosis are not unfrequent. Thus Richerand thought he had to deal with a sacro-iliac luxation; in Larrey's case the elongation of the limb gave the idea of dislocation forward of the femur. But in ordinary cases it is especially fracture of the cervix femoris with which this lesion may be confounded; shortening of the limb, eversion of the foot, crepitation elicited by pushing up the femur or by pressing upon the great trochanter, all these, as well as the nature of the determining cause, favor an error into which M. Gerdy admits that he himself fell. An excellent safeguard against it is the methodical measurement of the limb, by which we learn not only that the shortening is not in the thigh, but also that the anterior superior iliac spine is higher up than it should be. Thus put upon the track, the diagnosis is completely made out by seeking the signs of the anterior fracture in the perineum and fold of the groin, and those of the posterior back of the trochanter, while the existence of any of the displacements alluded to may be detected by the finger introduced into the vagina or rectum. The prognosis is rendered serious mainly by the injury inflicted on the viscera; but even when all danger from this source is past, we should not forget that from suppuration, which proved fatal in the patients of Richerand and M. Gerdy. Lastly, if life is preserved, lameness is very apt to ensue, or narrowing of the pelvis, the terrible consequences of which we have just seen.

The treatment, doubtless on account of the rarity of the lesion, has been very little attended to heretofore. Larrey states that in his case with elongation he succeeded in replacing the fragments by careful manipulation; but this is rendered uncertain by the fact that the limb remained elongated by more than an inch, and that the man could only walk with crutches.

Very little better success has been achieved in overcoming the shortening. Richerand says that in his patient it was very easy to bring the limb down to its normal length by traction, but that it went up again as soon as this was suspended; and as the traction gave great pain, it was abandoned, and no apparatus put on. Amesbury treated a fracture of this kind with his mechanical bed; but when the patient, being thought to be cured, was again put on an ordinary bed, the shortening was soon seen to reappear; and some

months afterwards, having refused to submit to further treatment, he had become entirely helpless, with a shortening of several inches. Lastly, M. Laugier tried an apparatus for permanent extension, on the plan of Desault's, in a young man of twenty, and gave him considerable relief. At the end of a month the patient was desirous of getting up and leaving the hospital; but three weeks afterwards the limb had become gradually retracted, although the callus was firm enough to sustain his weight in walking.*

It would seem from all these observations as if reduction would always be easy. But this may reasonably be doubted, if we consider that care has never been taken to measure the limb, any more than to ascertain the position of the iliac crest or of the tuber ischii. Nor can I see how permanent extension can be efficiently made from the ischium as a *point d'appui*, when the ischium is itself a part of the fragment which needs drawing down.

To sum up, it is necessary first to ascertain the exact relations of the fragments; if there is really shortening, to make extension on the leg, and counter-extension from the axillæ; but it must be seen that the fragment goes properly into its place, for which purpose one hand should act on the crista ilii, while the forefinger of the other, passed into the vagina or rectum, presses upon the tuber ischii. Of course if any other displacement, such as overlapping of the posterior by the anterior fragment, is detected, we should attempt to correct it by manipulation at the same time.

Reduction being made as completely as possible, it is to be kept up until consolidation is accomplished, that is to say, for at least forty-five or fifty days. The tendency to shorten is to be combated by means of a double inclined plane, the two thighs being fastened together so as to render them less movable, the feet fixed to the footboard, and the body confined by a loop placed beneath the axillæ. Against the other displacements, I know of nothing more efficacious than a very firm body-bandage, or what is better, a wide girdle buckled round the pelvis above the trochanters, with compresses to push the iliac crests inward if this be necessary; while a broad pad between the thighs, and a handkerchief fastening the knees together, would have the effect of carrying the two ischiatic tuberosities outward. It is in these cases particularly that a well-contrived bed is desirable, to enable the patient to be raised up and to go to stool without deranging the pelvis.

§ VII.—*Fractures in the Cotyloid Cavity.*

Most of these fractures being attended with displacement of the head of the femur, I shall postpone their more extended discussion

* Laugier, *Bulletin Chirurgical*, tome i, p. 66.

to the chapter on luxations of the hip-joint. But since the crepitation to which they give rise has sometimes led to the idea of fracture of the cervix femoris, and moreover as in some rare cases they exist without any concomitant dislocation, it has seemed to me to be better that I should say a few words here concerning them.

These fractures present quite numerous varieties. Courant saw one which divided vertically the ilio-pectineal eminence, the cavity, and the ischium. Sir A. Cooper has described and represented a stelliform fracture separating the three pieces of the os innominatum almost exactly at their line of junction, and Sanson met with a precisely similar case in a woman of thirty. In each of these cases the whole thickness of the bone was involved. Sometimes the injury is limited to the cavity itself; it may then be seated at its deepest part, as in a young man treated by Sanson, whose fracture was caused by leaping from a height, and in whom the bottom of each acetabulum was comminuted and driven into the pelvis without displacement of either femur; sometimes it is merely a part of the raised edge which is detached from the rest of the bone.

On the whole, if there is no appreciable displacement, the fracture only reveals itself by the crepitation, and would be with difficulty distinguished from a fracture of the cervix femoris unattended with shortening. The mistake would however be of very little consequence, the treatment in either case consisting merely in the maintenance of rest during the time required for consolidation. Any considerable displacement, throwing the head of the femur out of place, would belong properly to the same category with luxations.

CHAPTER XVI.

FRACTURES OF THE FEMUR.

Of all the bones, the femur is the one most frequently broken; it was affected in 308 of the 2328 simple fractures at the Hôtel-Dieu. But all parts of the bone are not equally so predisposed; thus of these 308 cases, 104 were in the cervix, 207 in the shaft, and five only, under the title of fractures of the knee, at the lower extremity. The small number of these latter forbids our deducing any statistics as to their principal predisposing causes; but fractures of the cervix and shaft offer a better field for such researches, and we shall meet with marked differences among them.

Fractures of the shaft are more frequent in men than in women, the proportion being 145 to 62. Those of the cervix are, on the contrary, somewhat more common in women; of the whole 104 but 48 were in men.

The diversity in respect to age is no less marked. Fractures of the shaft occur almost indifferently at all periods of life; 130 were in persons under forty, only 77 above that age. Fractures of the cervix are the almost exclusive portion of old age; under fifty years there were only fourteen; above, there were ninety. And the antagonism is far more striking if we compare the two forms of fracture in early infancy; thus from two to ten years I have known of but one fracture at the upper extremity of the bone, against twenty-one of its shaft. It may almost be said that at this age, of all forms of fracture that of the cervix femoris is the most rare; but we may certainly affirm that that of the shaft is the most common. There were of the patients at the Hôtel-Dieu, in all, sixty-three children of this age, and I have just said that of these twenty-one,—just one-third, had broken the shaft of the femur; and so also at the Hôpital des Enfants, of a total of sixty specified fractures occurring at that age, twenty-two belonged to the shaft of the femur,—a proportion very nearly the same.

The predispositions of each sex vary much, according to age. Of the fractures of the shaft, we find:—

From	2 to 20 years,	35 boys,	12 girls,	= 3 to 1
"	20 to 40 "	47 men,	6 women,	= 8 to 1
"	40 to 60 "	43 "	15 "	= 3 to 1
"	60 to 80 "	20 "	29 "	= 2 to 3

And of the fractures at the upper extremity:—

From 4 to 50 years,	9 men,	5 women,	= 2 to 1
" 50 to 60 "	9 "	10 "	= 1 to 1
Over 60 "	30 "	41 "	= 3 to 4

[During the five years between January 1, 1853, and January 1, 1858, there were treated at the Pennsylvania Hospital 196 fractures of the femur; and the following table will show the relations of age, sex, and seat of fracture:—

MALES.

	Total.	Neck.	Upper Th'd.	Middle.	Lower Th'd.	Not Stat'd.
Below 10 - - -	25	—	3	18	3	1
10 to 25 - - -	49	2	2	32	9	4
25 to 60 - - -	81	17	6	36	18	4
Above 60 - - -	12	7	2	1	1	1
	167	26	13	87	31	10

FEMALES.

	Total.	Neck.	Upper Th'd.	Middle.	Lower Th'd.	Not Stat'd.
Below 10 - - -	3	—	—	1	2	—
10 to 25 - - -	3	1	—	2	—	—
25 to 60 - - -	8	3	—	1	3	1
Above 60 - - -	15	12	—	2	1	—
	29	16		6	6	1

In five of these cases both thigh-bones were broken.
In two there was fracture of one femur in two places.
In one the great trochanter was broken off.]

The influence of the seasons is not very marked; but while during the winter season the fractures of the shaft of the bone are increased by one-twelfth, those of the cervix are more numerous by one-fifth.

Although all fractures of the femur come thus under three general heads, this division is quite insufficient for their close examination. At the upper extremity four very different varieties present themselves: those of the neck, intra and extra-capsular; those of the great trochanter; and those just below the two trochanters. Next come those of the shaft; and lastly, at the lower extremity, those just above the condyles, and those of the condyles which pass into the joint.

§ I.—*Intra-Capsular Fractures of the Cervix Femoris.*

This name is given to fractures dividing the cervix within the limits of the synovial membrane, so that if this membrane were di-

vided at the same level, the fracture would communicate at once with the joint. But as beneath the synovial membrane there is another layer covering the bone, a dense and solid periosteum, apparently a reflected portion of the fibrous capsule, it may easily be seen how this may either remain intact, or be partly or completely torn asunder, making three very different conditions under which the same fracture may occur. Stanley saw two cases of intra-capsular fracture, without any injury of the periosteum or of the synovial membrane; two other instances have been reported, one by M. Mayor and the other by Mr. Bransby Cooper.* The cases in which complete rupture occurs are almost as rare; it is undoubtedly most common to find the periosteum and synovial membrane partially torn across.

It is not only the soft parts that may escape complete separation; in some cases the bone itself is but partially divided. Colles has described three fractures of this kind, in which, the bone being broken transversely near its head, its cortical layer remained intact posteriorly in a good part of its width. In another case, described by Wilkinson King, the cortical layer was uninjured above and in front.†

But these are rare exceptions; in the immense majority of cases the fracture is complete, but offers some varieties in regard to its seat, its direction, and the arrangement of its surfaces.

Most commonly the cervix is divided very close to the head of the bone, at the point where it is narrowed; quite often, indeed, a small portion of the head itself is involved. Sometimes, again, a larger piece is separated, the division occurring near the trochanters. Béclard presented to the *Faculté* a specimen which he made out to be a fracture of the head of the femur into four pieces, perfect consolidation having occurred.‡ But the state of the surrounding parts, and especially of the cotyloid cavity, affords ground for doubt whether we have not here merely a senile deformity; and I know of no well-attested instance of fracture limited to the head of the femur.

As to the direction of the fracture, it sometimes divides the cervix perpendicularly to its axis, constituting a *transverse fracture;* sometimes it is oblique, when its course may vary. The fracture represented in *Fig.* 62 is oblique downward and outward; but which is perhaps the most usual direction. R. W. Smith has described fractures running downward and backward, downward and forward, etc.;§

* Stanley, *Medico-Chir. Transactions*, vol. xiii, p. 504, and vol. xviii, part i; Mayor, *Gaz. Médicale*, 1834, p. 612; B. Cooper, *L'Expérience*, tome i, p. 505.

† Colles, *Fracture of the Neck of the Femur, illustrated by Dissections; Dublin Hospital Reports*, 1818, tome ii, p. 334; W. King, *Guy's Hospital Reports*, Oct., 1844, p. 347.

‡ *Bulletin de la Faculté*, 1816, p. 86.

§ R. W. Smith, *Obs. on the Diagnosis and Pathology of Fractures of the Neck of the Femur; Dublin Journal of Med. Science*, Sept., 1840.

lastly, Sir A. Cooper mentions, on the authority of Brodie, an oblique fracture in which the upper fragment prevented the other from slipping up, and which therefore would seem to have passed downward and inward. It should be remarked that some of those oblique fractures extend beyond the limits of the synovial membrane, constituting *mixed* cases; that is, at once intra and extra-capsular. But as they do not perceptibly differ from those intra-capsular fractures in which part of the periosteum remains intact, I shall not examine them separately.

All these forms of fracture are generally serrated; and often the serrations are so large and firm as to keep the two fragments in perfect contact, or at least to limit their displacement. Displacement, indeed, cannot then occur unless one or more of these serrations is broken, forming so many splinters; and not unfrequently one of these splinters is seen buried in the spongy texture of the head of the bone. Sometimes the irregular end of the lower fragment is driven, without any splintering, into the substance of the inner piece or head; and lastly, there may be a mutual penetration; thus in one specimen at the Musée Dupuytren (No. 184,) the inner fragment, conical in shape, occupies a cavity in the middle of the end of the outer one; while the bevelled edge of this cavity has grasped the circumference of the head of the bone, in the same manner as is shown in the head of the humerus in *Fig.* 26.

Intra-capsular fracture is more common in women than in men, and occurs almost exclusively in old people. Sir A. Cooper sought to make of this double predisposition a sort of characteristic; and in his view the majority of fractures of the cervix femoris in persons over fifty years of age are intra-capsular. Recently a quite contrary opinion has been advocated; M. Bonnet, of Lyons, has even stated that extra-capsular fractures form the *immense majority*, and are *almost the only ones seen;** and M. Nélaton, without going so far, asserts that they are by far the most frequent.

Neither of these opinions is sustained by facts. Sir A. Cooper bases his opinion on his long practical experience, which is, however, an equivocal source of proof, owing to the obscurity of the differential diagnosis. M. Bonnet adduces clinical observation, experiments on the dead subject, deductions from anatomical structure, and lastly, autopsies. The first three of these sources may indeed furnish presumptive evidence, but not positive proof; and as to the fourth, it suffices to say that M. Bonnet, at the time when his Memoir was published, had seen in all but four dissections of fractures of the cervix, which might perhaps have just chanced to be extra-capsular cases.

In order to solve such a question, we need quite a large number of anatomical specimens, collected at random and without any pre-

* Bonnet, *Mém. sur les Fract. du Fémur*, etc.; *Gazette Médicale*, Aug. and Sept., 1839.

formed opinion. Now, putting together all the fractures of the cervix femoris preserved in the Musée Dupuytren in Paris, in St. Bartholomew's Hospital in London, in the two museums of the College of Surgeons in Dublin, and in the museum of the Richmond Hospital School, also in Dublin, I have arrived at the following results:

Musée Dupuytren,	32	fractures,	20	intra-capsular.
St. Bartholomew's,	12	"	6	"
Dublin Museums,	18	"	12	"
Richmond Hospital,	41	"	23	"
	103		61	

The proportion is therefore as three to two, or a majority of one-third for the intra-capsular form; I have not taken into the account two specimens in the Musée Dupuytren and Richmond Hospital Museum, in which is presented the very rare combination of one fracture within and another without the capsule.* Before this array of cases, arguments drawn from a few dissections, and even those giving contradictory results, fall to the ground. Thus after M. Bonnet of Lyons, who found four fractures in succession outside of the capsule, comes his pupil, M. Rodet, who in two other autopsies found the fracture to be within it. Thus also, M. Mercier, at Bicêtre, found in eight autopsies three intra-capsular fractures, four extra-capsular, and one below the trochanters;† while I myself, in the same hospital, found in eight other autopsies one fracture below the trochanters, five within the capsule, and only two outside of it.

On the whole, intra-capsular fractures, without being so frequent

* Some details as to the sources of these figures may perhaps be properly given here. The Musée Dupuytren contains thirty-five specimens of fracture of the neck of the femur; but two of them (Nos. 177 and 189) seem to me of very equivocal character; another, (No. 200,) is a gunshot fracture, and throws no light on the present question. M. Nélaton has asserted that the number of intra-capsular fractures in this museum is due to the fact that the specimens were collected at the time when Dupuytren was sharing in the discussion raised by Sir A. Cooper as to the mode of union of this form of fracture, so that they were preserved in preference. This is a mistake. Of the thirty-five specimens, but three were deposited by Dupuytren, and nearly two-thirds of the number by the *Société Anatomique;* so that after having made a resumé of the fractures presented to this society during the last eleven years, I have abstained from bringing them in for fear of making a double use of them.

The number of fractures in the museum at St. Bartholomew's was communicated to Sir A. Cooper by Stanley; that in the museum of the College of Surgeons in Dublin by Colles. Colles, in the memoir already quoted, reports a series of eleven autopsies made by him within three years, among which he found eight intra-capsular fractures. I have made use only of the numbers given to Sir A. Cooper, likewise for fear of making a double use of others.

Finally, the numbers from the Richmond Hospital Museum are quoted from the before-cited memoir by R. W. Smith. They comprise forty-two cases; but one of these, given as a specimen of a consolidated intra-capsular fracture, might be ascribed to an entirely different lesion.

† Mercier, *Mém. sur quelques partic. de l'hist. des fract. de l'extrém. sup. du fémur; Gaz. Médicale,* 1835, p. 561.

as stated by Sir A. Cooper, are more numerous than those of the other variety. A graver error is committed by the same author, in saying that they almost always occur in subjects over fifty years of age, whereas extra-capsular fractures are chiefly met with in younger persons. Morgagni examined by dissection an intra-capsular fracture in a woman of forty, who had sustained it in her youth;* Stanley saw another in a young man of eighteen; and it would be easy to spin out such a list of isolated instances. But of the twenty-three cases at the Richmond Hospital, three were in subjects not over fifty years old, and four others in persons below that age; while of seventeen cases of extra-capsular fracture in which the age was noted, only one was in a patient under fifty.

[In the United States, the general opinion is in favor of Sir A. Cooper's view. In the table on page 530 no separation is instituted between intra-capsular and extra-capsular fractures, both being included in the second column; this is because the record kept is deficient in this respect in reference to some of the cases; but of the seven male and twelve female cases of fracture of the neck of the femur in persons over sixty, every one followed the usual course and had the usual result of the intra-capsular form. Of the cases occurring in persons below sixty, nearly every one was produced by a fall or a direct blow over the trochanter, and from its course and result seemed quite plainly extra-capsular; those which deviated from this rule were all in persons verging toward the higher limit of the period.]

The determining causes are all indirect, except gunshot wounds, of which I shall make no mention here. Sir A. Cooper says that the most frequent cause in London is a false step, the subject walking along the curbstone and suddenly slipping into the street; the difference of level being several inches. The cervix femoris gives way, and the patient falls, his fall being the result and not the cause of the fracture. The lesion in question may however ensue from a fall upon the great trochanter. But Sir A. Cooper insists strongly upon the fragility induced by senile atrophy in the cervix, making it liable to fracture from the slightest causes; citing as an instance the case of a woman who was standing at her counter, and turning quickly toward a drawer behind her, caught her foot against a projection in the floor so that it could not follow the movement of her body; and this slight check was sufficient to break the cervix femoris.

All this is accurately described, but upon the living subject; and the question recurs whether it really applies to intra-capsular fracture. M. Rodet has lately endeavored to clear up the point by experiment;† he submitted to various forms of violence plaster models of the femur, and subsequently the bones themselves; and he divides all the causes of intra-capsular fracture into three classes, viz.:

* Morgagni, *De sedibus*, etc.; epist. lvi, art. 10.
† Rodet, *Thèse inaug.*, Paris, January 20, 1844.

(1.) Blows directed vertically, including falls on the feet or knees, and slipping off the curbstone as observed by Sir A. Cooper; the fracture occurs then the more readily, since the thigh is abducted, and the force acts on the head of the bone from above downward, and from without inward, relatively to the axis of its shaft. M. Rodet relates indeed the case of a man, who in falling out of a loft with his leg flexed and his thigh abducted, struck the inside of his knee against a horizontal beam; at the autopsy an intra-capsular fracture was discovered.

(2.) Blows applied to the trochanter from before backward, or any forcible rotation of the femur in this direction; the fracture is then at the middle of the cervix, and entirely within the capsule.

(3.) Blows applied to the trochanter from behind forward, or any forcible rotation of the femur in this direction; to this class would belong the case of the shop-woman mentioned by Sir A. Cooper. M. Rodet relates also the instance of a man who in falling backward struck the posterior face of the trochanter against an angular body, and had a fracture entirely within the capsule except a very small point at its back part, which was outside of it.

From his observations and experiments, M. Rodet concludes that *in general fractures of the cervix femoris present a certain relation between their seat and direction and the direction of the violence giving rise to them;* and he thus arranges the three orders of causes with their results:

Causes acting	Fractures
Vertically,	Oblique,
Antero-posteriorly,	Transverse,
Postero-anteriorly.	Mixed.

And finally, blows received transversely, as in falling on the side, inevitably produce extra-capsular fractures.

There is some truth in this theory, and I have seen some cases supporting it. An insane patient fell backward in going down a stairway, got up, and fell again, this time striking upon the mass of the right buttock; he died eight months afterwards, and I found an intra-capsular fracture. I have had represented (*Fig.* 65) a fracture produced by a like cause in an old man upon whom a trick was played, his chair being pulled away as he was sitting down in it. But in respect to falls on the side this theory is evidently deficient. The majority of our patients ascribe their fractures to falls of this kind; such was the case with the old man whose femur is shown in *Fig.* 62, as a type of intra-capsular fracture. M. Rodet's experiments are faulty chiefly in that they were made on the femur isolated from the pelvis, direct blows being inflicted at the base of the great trochanter. But in falls on the side, it is very rarely that the trochanter is struck in a transverse direction; the neck of the femur runs normally outward, downward, and backward, and conse-

quently the trochanter is a little back of the head of the bone; so that in a fall directly upon the side, it would strike by its anterior edge, and hence be acted on at the same time from without inward, and from before backward. This explains why, in the majority of cases, the periosteum and synovial membrane are torn anteriorly, and the fragments themselves separated anteriorly and driven together posteriorly.

Nor can we explain, with M. Rodet's three classes of causes, those very different cases in which the periosteum is torn in front and above, in front and below, or even above only;* and practice shows the true rationale, which is outside of his theory. I have seen an old man who being in danger of falling sideways, threw his body over the other way to catch his equilibrium, and in doing so felt a sharp pain in the hip, before he fell down; the fracture therefore occurred here from inordinate adduction. At another time, I was trying to produce a luxation downward and forward by violently abducting the thigh, in a dead subject eighty-one years of age, when suddenly there occurred a mixed fracture, that is to say, partly within and partly without the capsule. Lastly, the correspondence between each variety of fracture and each of the causes pointed out is far from being constant or certain; the fracture represented in *Fig.* 65, which judging from its cause should have been a mixed one, is plainly intra-capsular.

On the whole, from an attentive study of known facts, and from my own observations, I incline strongly to the opinion that, even in falls on the feet and on the hip, most of these fractures occur from forced movements of the hip-joint, adduction or abduction, or rotation either inward or outward. It is from similar causes that most luxations of the hip arise; the difference of result depends solely upon the strength of the capsule, which gives way in luxation, but resists in fracture.

Intra-capsular fractures, unattended with displacement, present no other symptoms than the local pain, and more or less impairment of motion in the limb. When there is displacement, which is most commonly the case, the following phenomena have been ascribed to them.

Pain; swelling of the soft parts; loss of power in the limb; shortening; drawing up and loss of prominence of the great trochanter; eversion of the foot; and finally crepitation. Each of these calls for special study.

(1.) The *pain* is located particularly in the fold of the groin, and according to Sir A. Cooper, at the level of the insertion of the psoas magnus and iliacus internus muscles into the lesser trochanter, or a little above this point. I have verified this statement in several

* See R. W. Smith, *op. cit.*, (in *Dublin Journ.*, Sept. 1840,) obs 5, 13, and 14.

cases; once I even saw the integuments raised up by the tendon of those muscles, which seemed as if they were shrunken. But I have also seen very severe pain caused by pressure posteriorly, either at the level of the trochanter or higher up.

Sir A. Cooper adds that the pain is less here than in extra-capsular fracture. But this seems to me a mistake, and I incline rather to just the contrary opinion. Generally the pain is but moderate in either case, and is easily assuaged by a proper position and by rest; but it is not uncommon to witness the most acute pain in intra-capsular fractures. Boyer relates an instance in which, from the outset, the patient complained of severe pain at the inner side of the thigh, and even around the knee; moderate extension, attempted at intervals, so increased this suffering, that it had to be given up. Swan saw a case in which the pain was so intense that opium had to be administered, and even this gave but little relief.* In one of my patients the pain was so severe and persistent that I was at first led, adopting the idea of Sir A. Cooper, to think the fracture an extra-capsular one. The subject of *Fig.* 62 was troubled for the first few days with cramps throughout the limb, and with terrible pains, which were increased by the slightest motion, and especially by coughing. On the sixteenth day these pains subsided; but at the end of two months, when I tried to make him get up, they recurred frightfully, affecting the hip and knee at the same time, and increasing upon the least motion; and they lasted thus for about six weeks. I then tried again to get him out of bed, but in vain; every movement was painful, and he was, like Boyer's patient, bed-ridden for the remainder of his life.

To what cause are such pains to be attributed? Not to the displacement, for in Swan's case there was no displacement, and the fracture was found in great measure united. I think they are due to inflammation, set up in the hip-joint and radiating by sympathy to the knee. In the second of my two patients, who died in five months and a half after the accident, the round ligament was mixed up in one reddish mass with the fatty pad at the bottom of the cotyloid cavity; and union had been commenced, by means of reddish false membranes, between the head of the femur, the cotyloid cavity, and the capsule. In the other, who survived the injury more than eight months, besides a similar agglutination of the round ligament, the head and neck of the femur had contracted very firm adhesions above and in front with the capsule, and at the points occupied by these adhesions the synovial membrane and the articular cartilage had disappeared.

(2.) The *swelling* is generally very slight; in one case, however,

* Sir A. Cooper, *Lettre sur les fr. du col du fémur; Gaz. Médicale*, 1834, p. 503.

I saw it extend from the hip down to the knee. I do not know at present of any instance in which it has been attended with any ecchymosis externally; but it should be mentioned that in Boyer's case, just quoted, the autopsy revealed an effusion of blood into the substance of the quadriceps femoris muscle; and that Swan also found by dissection some ecchymosis among the muscles around the fracture, as well as in the cellular tissue around the sciatic and anterior crural nerves.

(3.) The *loss of power in the limb* generally includes all the voluntary movements. Thus the patient cannot rise, nor stand upon the injured limb; when he is lying down, he cannot adduct or abduct it, or rotate it either outward or inward. Boyer has strongly insisted on one phenomenon in connection with the loss of power; the patient, says he, cannot raise the limb as a whole, and his endeavors to do so have no effect except to produce a slow and limited flexion of the leg and of the thigh, and to approximate the foot to the buttock, without raising it off the bed.

There are in this respect notable exceptions. Thus the subject of *Fig.* 62 raised his foot with ease off the bed, although I had clearly made out a shortening of an inch. The subject of *Fig.* 65 got up after his fall, regained his chamber, and walked again the next day; and most observers have cited analogous facts.

How are these anomalies to be explained? Desault alleged the interlocking of the fragments; to which Boyer adds the resistance of the uninjured periosteum. These are doubtless favorable circumstances, but they do not sufficiently account for the phenomenon; thus in one of Stanley's patients the contact of the fragments was as exact as possible, and yet the limb had lost all power of motion. On the other hand I had assured myself of shortening, and hence of the disjunction of the fragments, in the old man who could raise his whole limb; and although the displacement had not been noted at the outset in the other patient who walked just after his fall, yet the autopsy subsequently showed very great shortening. Sometimes again, on the subsidence of the pain and irritation, patients with shortening can stand very well on the injured limbs; why could they not do so at first? What hindered them was just the pain; and here, as in fractures of the clavicle, the severer the pain the more difficult is any movement which will aggravate it; with less pain or with more fortitude, some patients can attempt motions and efforts which to others would be impossible. Only, what it seems to me important to notice, these movements are now accomplished not by the hip-joint, but in great part at least by the lumbar portion of the spinal column.

(4.) The *shortening of the limb* seems to strike the eye first from the relative position of the heel, of the malleoli and of the knee, to those of the sound side, the former being on a higher level. But

the surgeon should bear in mind the small value of all these signs. The drawing up of the heel, of the malleoli, of the knee, by no means indicate that the limb is shortened, but only that the pelvis is tilted up. To show how uncertain a dependence is to be placed upon them, we need merely cite an instance from M. Mayor, in which were observed *at ten paces the well marked characters of fracture* of the cervix femoris, while the autopsy revealed only a *scarcely perceptible* fissure. We must therefore seek to estimate the shortening with accuracy, and for this purpose should resort to methodical measurement, according to the rules laid down in the article on *Diagnosis*.

This being understood, it is important to know what may be the extent of the actual shortening, and first under what circumstances it takes place.

The head of the femur, the shaft being held vertically, is sometimes as much as two-thirds of an inch above the summit of the great trochanter; this is represented by the dotted lines in *Figs.* 62 and 63 in a femur belonging to a subject seventy-six years old. Sometimes again it is much lower; in an old man of eighty-seven, (*Fig.* 68,) its elevation reaches scarcely one-third of an inch. When the cervix is fractured and the limb shortened, it is because the head descends below its natural level; but taking the summit of the trochanter as the point for comparison, it is easily seen that the shortening may vary by at least one-third of an inch, while the head is in just the same relative position to the trochanter.

This lowering of the head takes place in two ways. Sometimes the outer or lower fragment rises, not leaving the upper one, but carrying it up also; so that the surfaces of the fracture are separated above, and the head of the femur, unable to ascend, remains inclined downward, below its normal level. The shortening cannot in such a case amount to much; I have in my possession a specimen of the kind, in which, the head being brought down on a level with the top of the trochanter, the actual shortening is not more than from one to two-thirds of an inch. Sometimes again, while the head of the bone is thus inclined, the fractured surfaces slide over one another, constituting a real overlapping; *Figs.* 62, 63 and 64, display such overlapping, combined with tilting over of the head of the bone, and with separation of the fragments superiorly. The head in these cases descends much more than in those before spoken of; still, even if unimpeded by any interlocking between the fragments, it always at last encounters two obstacles to its further progress; one is the resistance of the capsular ligament, the other the projection of the lesser trochanter. *Figs.* 63 and 64 show this latter condition very plainly, although the head has been arrested some millimètres from the point named; and the actual shortening amounted to nine-tenths of an inch. I have another preparation in which the fracture is mixed, and somewhat further from the head of the bone; the over-

lapping is a little less marked; but on the other hand, the inclination of the head is a little more so; the head has here been arrested only by the lesser trochanter, and as it is found to be one-third of an inch below the great trochanter, the shortening may, according to its normal degree of elevation, amount to two-thirds of an inch merely, or to a full inch; but the latter is in my opinion its maximum.

This examination of nature enables us to estimate the various opinions of authors, judging them by their own facts. Sir A. Cooper assumes in the first place that the shortening varies from one to two inches; subsequently he adds that the head is sometimes arrested at the lesser trochanter, and that then the shortening does not exceed half an inch; and among his plates may be seen a drawing of a fracture given to him by Mr. H. Mayo, in which the arrest of the head by the lesser trochanter has given rise to a shortening of one inch. R. W. Smith has given another specimen of quite as curious logic, in fixing an inch and a half as the extreme limit of the shortening, while in not one of his observations did it exceed one inch.* Again M. Brun, from experiments upon the dead body, declares that he could never get a shortening of more than one-half to two-thirds of an inch; M. Rodet, from analogous experiments, made it out at most two-thirds of an inch; but this is all they could expect, if the head of the femur before the fracture was not more than one-third of an inch above the greater trochanter.

Thus then in recent intra-capsular fractures the actual shortening may attain various degrees; but the double resistance of the capsular ligament and of the lesser trochanter will prevent its exceeding one inch.

In regard to this there is one very important observation to be made. Quite commonly the shortening is at first either wanting or hardly perceptible; afterwards it suddenly appears and becomes quite marked, some days or even weeks after the accident. Probably in these cases the fragments have been kept in contact either by their serrations or by the resistance of the periosteum; subsequently some incautious movement overthrows these obstacles, already enfeebled by the double effect of inflammation and absorption occuring at the seat of injury. An old man presented pain, swelling, and impairment of motion, but no shortening, in consequence of a fall upon the hip. Hesitating whether to consider it a contusion or a fracture, I put it on a double inclined plane, and so maintained it for three weeks. The pain having now disappeared, and there being no shortening, I thought it had been a mere contusion, and removed the apparatus. Two days after that he had a shortening of more

* I exclude fractures of long standing, which will come up hereafter; and also one case of recent fracture in which the joint had been partly destroyed by the suppuration. Yet in this exceptional case Smith makes out the shortening only an inch and a quarter, or thirty-one millimètres.

than two-thirds of an inch. I have seen another case entirely similar to this one, and perhaps there is no other symptom of intra-capsular fracture which is so positive.

Lastly, the shortening, in the conditions revealed by pathological anatomy, is accompanied by certain secondary phenomena which are worthy of our serious attention. Consider in *Figs.* 62 and 63 how much of the head and neck of the femur, in the normal state, is outside of the cotyloid cavity, and serves for the abduction of the limb; and compare this with what remains after the fracture. It is quite evident that the upper edge of the cavity, in this specimen, was nearly in contact with the edge of the outer fragment, which would strike against it on the slightest effort at abduction; while no such obstacle exists to adduction. But *Fig.* 62 shows most distinctly that if flexion is attempted, in order to the easy motion of the head in the articular cavity the femur should be carried a little outward, and that if flexion be combined with adduction, the outer fragment would almost immediately strike against the anterior border of the cavity.

Thus is explained the increase of the pain by abduction, as pointed out by Louis,* and by adduction combined with flexion, as remarked by Sir A. Cooper.

(5.) The *riding up of the great trochanter* toward the crista ilii, is an inevitable consequence of actual shortening; but during life the thickness and sometimes the swelling of the soft parts prevent our clearly perceiving it, and M. Nélaton goes so far as to say that *most commonly it does not take place.* According to him the trochanter, going at once upward and backward, comes thus into relation with a more elevated portion of the crista ilii; so that the interspace between the two may very readily be not only as great, but even greater.

This displacement backward of the great trochanter, observed by Desault, is more in the appearance than in the reality. In some cases the outer fragment is even thrown a little in front of the other; I have a specimen in which this is very evidently the case. When on the other hand it is carried somewhat backward, it is only by a few millimètres, and there is at the same time a rotation approximating its posterior edge to the head of the bone and consequently to the iliac spine. Its anterior edge is by this movement carried a little backward, and from this arises the deception; but if we examine the summit of the process, we find it rather brought nearer to the anterior superior spinous process, and therefore carried a little forward. Thus it is very certain that in all cases of shortening of the limb the trochanter is approximated to the iliac spine. How then can we explain the error of an observer like M. Nélaton? Probably from his having had to deal with extra-capsular fractures, in which the conditions are very different.

* *Mém. de l'Acad. Royale de Chirurg.* tome iv, p. 650.

Sir A. Cooper overlooked this displacement backward; but he says that the prominence of the trochanter is obliterated, seeing that it is carried in close to the edge of the cotyloid cavity. It is the posterior edge of the trochanter which is approximated to the cavity; but its anterior edge is quite as far from this as in the normal state, and we see in *Fig.* 62 that the interspace between the head of the bone and the trochanter is nearly equal in the injured to what it is in the sound bone. The apparent obliteration and the displacement backward are two different interpretations of the same phenomenon, namely, the rotation of the bone. If the fracture be of some weeks' standing, little as the buttock may have fallen away, the trochanter will seem more prominent than on the sound side; and this is equally far from the real state of the case.

(6.) The *eversion of the foot* is another result of the rotation of the greater trochanter, much more easily comprehended. Care must be taken lest we confound with this the natural inclination of the foot, and that we do not lose sight of its essential character, viz., that the foot rests on the bed by its entire outer edge, the heel pointing directly toward its fellow. In case of any doubt, M. Gerdy has indicated a sure means of avoiding error, which is to increase the rotation until the toes point outward and a little backward; this being almost impossible, if the pelvis remains fixed, and the cervix femoris is unbroken.*

The eversion is not constant. In the first place there are numerous cases in which it is absent during the first few days, only presenting itself at a period more or less advanced. In other cases the foot maintains its normal position throughout; and lastly there are cases in which it falls inward; of this A. Paré and J. L. Petit have each given an instance; Desault thinks it occurs in about one case out of every four, and I for my part have several times seen it. Guthrie, it is true, denies that it can take place in recent fractures within the capsule, but Stanley proved by an autopsy that one case was entirely intra-capsular in which, from the very first, the foot was turned inward.† This inversion occurs to quite as marked a degree as the eversion; the foot lies on the bed by its whole inner edge, and in the subject of *Fig.* 67 this fact, combined with the decided adduction of the limb, led me into error, giving me the idea at first of a luxation of the hip.

What is the origin of these differences? Rotation outward is quite generally accounted for by muscular action; but hitherto rotation inward has not received any such explanation. In 1833, having found the foot inverted in a fracture of the neck of the femur, I

* Gerdy, *Obs. et Réfl. sur les fract. du col du fémur; Arch. Gén. de Médecine,* 1834, tome vi, p. 371.

† Guthrie, *Medico-Chirurgical Transactions,* vol. xiii, p. 103; Stanley, *ibid.* p. 508.

ascertained that it was easily everted and again inverted at will, and that it remained as readily in one position as in the other; whence I concluded that whatever inclination is given to the part upon the supporting plane, it keeps by its own weight;* M. Mercier subsequently made the very just remark that in carrying the patient his limbs are generally kept together, and the sound foot hinders the one on the injured side from turning inward, leaving it to follow its natural inclination and to gravitate outward.

A deeper study of the facts has greatly modified my views in regard to this point. We must first determine by what mechanism the foot is turned. When the fragments are held in place either by their serrations or by the periosteum, the limb may be rotated either inward or outward at pleasure, but only within the normal limits of this motion; there is no displacement at the seat of fracture, nor distortion of the limb. Still, even then this freedom of motion does not exist after the first or second day; the muscles contract around the injured joint, preventing motion just as in an ordinary contusion or arthritis. Sometimes, when the limb is left to its own weight, this by its continuous action at last stretches the bands which hold the fragments together; the outer fragment inclines backward; there is then angular displacement, and a rotation of the foot beyond the normal limits; which explains those cases in which the foot, at first in good position, inclines more and more until it falls over completely.

But it is far more common to meet with this rotation immediately after the accident, when it is a certain sign of actual displacement due to the fracturing cause. In the case of rotation inward observed by Stanley, the synovial membrane and periosteum were torn through completely, except in front; whence we may infer, in spite of the want of further details, that the trochanter had been carried so strongly forward as to make between the two fragments an angle salient posteriorly. As to eversion, the proofs are abundant. I have already alluded to a specimen in which the fragments are separated above so as to let the head of the bone down below the level of the trochanter; there is likewise in front a separation of over one-third of an inch, and the outer fragment seems to project a little in this direction, while posteriorly it is driven into the spongy texture of the inner one. I have another specimen in which it is, on the contrary, the inner fragment which overlaps the other in front by nearly one-third of an inch, and which posteriorly is buried in its spongy tissue; and as at the same time there is considerable shortening, the result of this double displacement has been to bring the lesser trochanter below the head of the femur.

The Musée Dupuytren contains several analogous preparations. It is evident that in such a case it would be impossible to rotate the

* *Gazette Médicale*, 1833, p. 318.

foot inward, without overcoming the impaction of the fragments, and employing a very considerable degree of force.

Are there not nevertheless some exceptional cases, in which, the fragments being completely separated, and in no way hindered from inclining at an angle in either direction, rotation is possible either inward or outward, and to any degree? This is probable, but I have no facts by which to prove it.

Eversion of the foot is almost always accompanied by two other phenomena, viz.: a projection of the anterior part of the cervix forward, and a narrowing, sometimes to an extreme degree, of the hollow between the head and the great trochanter posteriorly. These are easily observed in anatomical specimens, and I have sometimes been able to detect them during life.

(7) *Crepitation* is in these cases elicited with difficulty. Sir A. Cooper says that we may obtain it by drawing the limb down to its natural length, and then rotating it, especially inward. It may sometimes be perceived also, he adds, by placing the patient upright upon his sound limb, and then giving a rotary motion inward to the one affected, which will be elongated by its own weight. I apprehend that this direction, to stretch the limb, is dictated by an erroneous theory, with a view of bringing the fractured surfaces in contact; while in fact they have never completely abandoned one another. Nothing, however, need prevent our testing it practically; I can only say that for my own part, in cases in which the diagnosis has been incontestably verified by dissection, I have never during life succeeded in producing crepitus.

What now is the course, and what are the terminations of this fracture? We say first, that the most general fact concerning it is the want of bony union between the fragments. This has been long contested, and has long been accounted paradoxical; it took Sir A. Cooper no less than twenty years to effect its definite admission by science. He explains this want of consolidation upon three grounds: (1) the riding up of the outer fragment, preventing coaptation; (2) the excessive secretion of synovial fluid, the inevitable consequence of the injury to the joint, and the effect of which is to separate the fragments by pushing the outer one farther out; (3) lastly, the low vitality of the inner fragment, which receives its nutriment only through the scanty vessels of the round ligament, and of that portion of periosteum between the fragments which may remain unbroken. This last reason is assuredly the principal one.

There have, however, been reported quite a number of instances of bony consolidation. Amesbury has collected four such, from Langstaff, Brulatour, Chorley, and Field; I have already cited those of Swan and Stanley; M. Chassaignac ascribes another to Van Houte;* one is quoted from Adams by R. W. Smith; and lastly, the

* Chassaignac, *Thèse inaug.*, Paris, 1835.

Musée Dupuytren contains three specimens which have been so described. This limited number of cases, carefully brought together ever since the question was raised, shows how rare bony union must be; but it must be added that even in regard to most of these there is too much ground for uncertainty. Thus the four cases collected by Amesbury, as well as that of Adams, much more closely resemble rachitic alterations of the cervix than veritable fractures; I must say the same of Nos. 177 and 189 in the Musée Dupuytren; and it suffices to study the beautiful drawings given by Sir A. Cooper of some of these alterations, to put us on our guard against any so-called consolidation with shortening and deformity of the head and neck of the bone. When a fracture unites, the fragments do not undergo such enormous losses of substance as we should have to admit in the neck of the femur; and in Swan's case, which Sir Astley Cooper himself acknowledged as an instance of bony union, the neck of the bone had not changed its form. It was so also in Stanley's case; and lastly, one femur, (No. 188,) in the Musée Dupuytren, has lost nothing either in form or volume except as the result of a very trifling displacement. I admit that these three examples demonstrate quite positively the existence of consolidation; but I cannot say the same of any of the rest.

[Dr. R. D. Mussey, of Cincinnati, in an article on *Fractures of the Neck of the Thigh-bone*, published in Hays' *American Journal* for April, 1857, gives five cases of intra-capsular fracture, four of which he himself treated and subsequently dissected, the fifth being without history; another, without history, is almost entirely intra-capsular, but not quite. In three of Dr. M.'s cases union took place by bone, and in one by fibrous tissue; in the fifth specimen it was ligamentous, and in the sixth bony.

Dr. Henry H. Smith has remarked, in his text-book on surgery, that in all the cases of bony union within the capsule, the fracture is seated very close to the head of the femur; assigning as an explanation of this fact the more ready nutrition of a small fragment by the vessels running along the ligamentum teres, and the greater chance of the periosteum remaining intact than when the fracture is nearer the trochanters.]

Now let us see what are the results of experience as to the course of these fractures. Slightly as the periosteum and synovial membrane may be torn, there is an effusion of blood within the joint; soon after this, inflammation is set up to a greater or less degree, and gives rise to an abundant synovial secretion, with shreds of fibrin floating in it. Subsequently absorption takes place; and at last, according to the degree of contact and of the vitality of the fragments, they are found to be united by fibrous or fibro-cartilaginous tissue, or perhaps merely by fibrous bands of greater or less length; or, finally, union may be entirely wanting, the fractured surfaces re-

maining quite unconnected. *Figs.* 62, 63 and 64 represent a fracture dating back six months and a half; at those points where the fractured surfaces were in contact, they are joined together through the intervention of fibro-cartilage; lower down the inner fragment, in relation with the inferior wall of the cervix, is attached to it by scattered fibrous bands; and lastly, at the circumference there is found a very dense fibrous tissue, continuous externally with the subsynovial periosteum, and below with the capsule itself, both the latter membranes being reddened and thickened. *Fig.* 67 shows union by longer and much less resisting fibrous bands; and in *Fig.* 65 there has been no union at all.

It is very remarkable that here the periosteum covering the two fragments does not, as in ordinary fractures, throw out any ossific matter. There are almost never found near the fracture those bony deposits attributed to the provisional callus; and when, by chance, they are met with, they belong almost exclusively to the outer fragment. It is the capsular ligament which is here most efficient in maintaining the relations of the broken ends, in default of their direct union; frequently it becomes thickened, assuming a consistence like that of cartilage; Colles saw it in one instance a quarter of an inch thick throughout, and in some places half an inch. It may even undergo osseous transformation; in one of R. W. Smith's observations, a concave plate of bone, three inches in length and one inch wide, occupied the anterior portion of the capsule; Langstaff has described a similar specimen; and No. 135 in the Musée Dupuytren affords a remarkable instance of a like deposit. Lastly, I have received from M. Teissier a specimen, already described by M. Manzini, in which a bony mass of nearly seven inches in circumference by two or three in thickness, surrounds at once the trochanter and the two inter-trochanteric lines, as if to give the pelvis a *point d'appui* upon the femur.

A different action goes on between the two fragments, especially when there is no union of any kind. In the specimen represented in *Fig.* 62, all that part of the broken surface of the outer fragment which is above the level of the other is coated with a kind of white, smooth cartilage, like that of incrustation. Lower down, where the two fragments look toward one another without being in contact, there are on the outer one bright red granulations, doubtless the commencement of an incrusting cartilage. Neither granulations nor cartilage are to be seen on the inner fragment. After having traced in this specimen the first two stages of the process of incrustation, by granulations and cartilage, the final result is seen in *Figs.* 65 and 67, representing very old fractures; the outer fragment is covered with osseous plates, thick, smooth and ivory-like; the inner one shows nothing of the kind.

Sir A. Cooper has asserted, and many other writers have followed

him, that the portion of the neck which remains attached to the trochanters undergoes an absorptive process by which it is in great measure destroyed. This is a capital error. Certainly, in glancing superficially at the outer fragment in *Fig.* 65, and especially in *Fig.* 67, one is struck with the almost total disappearance of any prominence resembling the cervix; but if the thickness of the bone at this point be accurately measured, it is easily seen to be not at all diminished; and it will be found that, although the projection of the cervix is rounded off at its upper angle, its thickness is rather increased below by the addition of the eburnated plates above alluded to.

It is quite otherwise with the inner fragment. In *Figs.* 62 and 63 the beginning of its absorption may be observed; and in the subsequent figures this is seen to reach a very marked degree. *Fig.* 65 shows the head hollowed out by the rounded extremity of the outer fragment; but in *Fig.* 67 it presents, on the contrary, irregular projections. But in order to give a better idea of the progress of this wasting I have accurately measured in these three specimens the thickness, through the head and the great trochanter, and have found:

Fig. 62, femur in the normal state -	91	millimètres	($3\frac{1}{30}$ inches.)
" " with the fracture -	91	"	"
Figs. 65 and 66 - - - - - -	86	"	($2\frac{9}{10}$ inches.)
Figs. 67 - - - - - - -	76	"	($2\frac{8}{15}$ inches.)

Why should there be such a difference between the two fragments? I have no hesitation in ascribing it to the difference in their vitality. The outer fragment, highly vitalized, resists, grows, and hardens beneath the pressure; the other wastes away.* There is seen in the section of the head of a femur represented in *Fig.* 63, a light-colored spot answering to its upper portion, where the wasting is most marked. This spot was yellowish in the fresh specimen, and much harder than the rest of the fragment, which was of a beautiful red color; it was harder even than the spongy texture of the outer half of the trochanter, which presented nearly the same yellow color. This was so marked, that I could not divest myself of the idea of a partial necrosis; and without wishing to assert that this portion of the bone was totally altered, I think at least that its nutrition was already insufficient, and that to this fact was owing its slight resistance either to wear or to absorption.

Lastly, at the same time that the inner fragment wastes away, the riding up of the femur is increased by the weight of the body and

* Brunninghausen has even reported a case in which the head of the femur entirely disappeared in consequence of a fracture of the cervix, and R. W. Smith credits Banco with another of the same kind; but I think there has been some error here. See Brunninghausen, *Sur la fr. du col du fémur; Biblioth. Germanique*, tome iii, p. 114.

by the action of the muscles; if the capsular ligament is not thickened or ossified, it at length becomes stretched, and the head of the bone gradually passes down below the lesser trochanter. The commencement of this descent is seen in *Figs.* 65 and 66; the lesser trochanter has been wasted by the friction, covered with an eburnated layer, and incased in a synovial membrane. But this friction was only sustained during flexion; at other times the head remained at a higher level; the capsule itself has been intact below, and there the shortening has amounted in all to only an inch. In *Fig.* 67 the descent has been inordinate; the lesser trochanter has entirely disappeared, and is blended with the eburnated surface of the outer fragment; and the tendon of the psoas muscle presents a bony plate supporting the head of the bone anteriorly. The real shortening was nearly two inches; but the thigh being at the same time slightly flexed and excessively adducted, and the pelvis drawn up on the affected side, the whole amount of shortening was hardly less than three and a half inches. Sir Astley Cooper quotes from Langstaff the case of a man who was obliged, in order to equalise the two limbs, to wear a sole four inches thick.

Hence we see what difficulties the patient must meet with in trying to use the limb. Except in the very rare cases in which the fragments are kept in contact by ossific callus or by strong fibrous connections, the femur rides up, and the limb becomes shortened until the head bears against the lesser trochanter; indeed it is fortunate if the shortening goes no further. The patients are unable to walk without support; some can get along with a stick; many require a crutch; others need both a stick and a crutch, or even two crutches; and among these latter, many carry the injured limb as a mere dead weight, being unable to rest on it in the slightest degree. The pelvis being commonly drawn up on this side, the limb is more or less adducted by its own gravity, and generally is also slightly flexed. But I would call attention especially to the motions of the hip, which I have studied with some care both in the living and in the dead subject.

The thigh may in general be passively moved on the pelvis with great freedom; it may be flexed, extended, carried outward or inward, or even rotated; and although undoubtedly all these movements are somewhat more limited than those on the sound side, still they do take place, either in the normal articulation or in the false joint, the pelvis remaining fixed. The will, on the contrary, can hardly command any mobility at all; most of the motion in this case is in the lumbar portion of the spinal column; in some instances it takes place wholly there, the muscles of the thigh serving only to fix the pelvis, and the limb having lost one joint. So that, what is remarkable, in these latter cases the neck of the bone has both a true and

a false joint, and yet it is as useless for voluntary motion as if it were firmly anchylosed.

Hence the muscles of the hip, rendered almost entirely inactive, lose their volume; I have seen the gluteus minimus in a state of fatty degeneration, and the tendon of the psoas ossified in its groove. Thus the buttock becomes flattened, or even hollow; the trochanter seems more prominent, and is evidently approximated to the iliac crest, more especially to the anterior superior spine. In a specimen in my possession, comprising the pelvis and both femurs, when the pelvis rests exactly upon the middle portion of the sacrum the trochanter of the sound side is nearer the ground by half an inch than that of the other. The rest of the limb always participates more or less in this atrophy.

Guthrie quotes a case from Langstaff, in which the foot was at first everted, but was brought inward when the patient began to use his limb. But this was an exceptional instance; and I have dissected several intra-capsular fractures of long standing, in which the eversion of the foot remained.

I shall not dwell here upon the diagnosis, which can be better and more completely discussed in connection with extra-capsular fractures.

The prognosis is always grave; with very rare exceptions, a patient with intra-capsular fracture will be lamed for life, and sometimes even lose the use of his limb entirely. There is besides at the outset a still greater danger to be warded off. Of the twenty-three subjects from which the specimens in the Richmond Hospital Museum were obtained, six died at from the seventh to the seventeenth day, with all the symptoms of low inflammatory fever, occurring sooner or later after the accident. The period of life has but little to do with this result; three of these cases were above seventy or even eighty years, but the three others were below fifty-one. One more patient, forty-one years old, should be added, who died on the thirtieth day in consequence of a very large abscess in the joint, complicated with acute osteitis in the femur; so that death seems to have selected in preference the more youthful patients.

The treatment is very far from being fixed.

The ancient school, still represented by Boyer, held that the want of union in these fractures depended solely on want of contact and of sufficient apparatus; whence they attached great importance to reduction, and contrived a variety of plans for making permanent extension.

Another school, with Sir Astley Cooper at their head, regarding consolidation as impossible in the immense majority of cases, abandoned all attempts at reduction and all forms of apparatus. "I should," says Sir Astley, "if I sustained this accident in my own person, direct that a pillow should be placed under the limb through-

out its length, that another should be rolled up under the knee, and that the limb should be thus extended for ten days or a fortnight, until the inflammation and pain had subsided. I should then daily rise and sit in a high chair, in order to prevent a degree of flexion which would be painful; and walking with crutches, bear gently on the foot at first; then gradually more and more, until the ligament became thickened, and the muscles increased in their power. A high-heeled shoe should be next employed, by which the halt would be much diminished. Our hospital patients," he goes on to say, "treated after this manner, are allowed in a few days to walk with crutches; after a time a stick is substituted for the crutches, and in a few months they are able to use the limb without any adventitious support."

Sir Astley has nevertheless duly acknowledged the danger of this course on account of the uncertainty of the diagnosis. "In every case, however," says he, "in which there is the smallest doubt whether it be a fracture within or external to the ligament, it will be proper to treat the case as if it were the fracture which I shall hereafter describe, and which admits of ossific union."

This might be sufficient in practice, since in fact our uncertainty never is completely removed. But even if the surgeon had the assurance which is wanting, I say that besides bony union there are other objects to be aimed at. It is not a matter of indifference whether the patient has a very slight or a very considerable shortening; and we can only hope to regulate this by keeping up the interlocking or the interpenetration of the fragments, by maintaining the sound condition of the periosteum, and by favoring union by a fibrous tissue as short and thick as possible; now this triple indication cannot be fulfilled except by immobility and a good position of the limb. It is well also to correct the inclination of the foot, whether outward or inward. Hence there is, within certain limits, a necessity for making and maintaining reduction.

We should never make reduction with the view of elongating the limb. If the shortening is slight, we should by so doing risk the disengagement of the fragments; if it is considerable, the periosteum must have been a good deal torn, and the reduction, which must be made by means of permanent extension, would in no way promote the impossible union of the entirely isolated fragments. All that can prudently be done is to restore the proper direction of the foot, at the same time raising the trochanter, and pressing carefully upon the anterior face of the cervix femoris. It would be better even to leave the foot everted, than by the employment of force to risk destroying the mutual penetration of the fragments.

Our attempts at retention should be confined to keeping the foot in proper position, preventing any increase of the shortening, and insuring as much as possible the immobility of the limb. The double

inclined plane, with a solid foot-board, has seemed to me to offer the greatest advantages and the fewest inconveniences. For the rest, although union, whether fibrous or bony, requires but forty or fifty days, the apparatus should always be left on somewhat longer.

The severe local pains should be allayed by emollient cataplasms. Sir A. Cooper apprehends in these cases some injury to the general health from prolonged confinement. I have before shown, in speaking of one of the most alarming of these symptoms,—sloughing over the sacrum,—that they are never brought on by mere want of motion, (*ante*, p. 236.) As to the general affections which may give rise to them, and which too often destroy the life of the patient, they commonly develop themselves almost immediately after the accident, and rest in bed, so far from causing them, is one of the essential and unavoidable conditions of their treatment.

If, lastly, after the time required for either bony or fibrous union, the first attempts at walking made by the patient augment the shortening to any notable degree, an entirely new indication is presented, which I believe was first pointed out by me; it is to surround the pelvis below the iliac spines with a well-padded leather girdle, strongly fastened with buckles, to obviate as much as possible the riding up of the great trochanter.

§ II.—*Extra-Capsular Fractures of the Cervix Femoris.*

In this form of fracture the neck of the bone is generally detached at its base, along the oblique line running in front from one trochanter to the other, and along the inner edge of the corresponding line posteriorly. This is in some sort its normal type; but it may be seated nearer to or farther from the capsule; and hence arise two varieties, both of which are, however, quite rare.

When the seat of the fracture is a little farther inward, the case hardly calls for any special mention; only the insertion of the capsule into both the fragments will prevent any very considerable separation of them. But when it is located farther outward, it divides the greater trochanter, which then forms a part of the upper fragment; Guthrie, R. W. Smith, Mercier, Michon, and Nivet have met with cases of this kind.*

Besides these differences in their seat, extra-capsular fractures may be partial or complete, single or multiple.

A too superficial examination of fractures of long standing led Adams† to a belief in incomplete fractures, in which, says he, the

* Guthrie, *Medico-Chir. Transactions*, vol. xiii, p. 103; R. W. Smith, *op. cit.*, obs. 30; Mercier, *op. cit.*, *obs.* 3; Michon, *Bulletin de la Soc. Anatomique*, 1835, p. 37; Nivet, *ibid.*, 1836, p. 182.

† Adams, *Mém. sur la fract. incomplète du col du fémur; Gazette Médicale*, 1835, p. 641.

compact tissue of the upper wall of the cervix femoris presents no change unless it be that the entire neck has assumed a horizontal direction; while the inferior wall, evidently broken, is driven into the spongy tissue of the outer fragment, so as to make with the inner wall of the shaft something like the letter T. [See *Fig.* 71.] According to this, *Figs.* 70 and 71 present all the characters of partial fracture; but we need only look at the inclination inward of the great trochanter to be convinced that there is something more than this; and the study of the specimens themselves would remove all doubt on the subject. I know of but one instance of incomplete extra-capsular fracture; it was found by M. Tournel in an old man of eighty-five, who had had a fall upon his buttocks. He died three months and a half afterwards; the autopsy revealed a long crack in the bone, the upper part of which corresponded to the digital fossa within the great trochanter, and which in front and behind was prolonged into two fissures terminating externally a little below the level of the lesser trochanter. It was then, contrary to Adams's hypothesis, the inferior wall of the cervix which had resisted.*

[In the paper of Dr. Mussey, alluded to in a note to the preceding section, mention is made of a specimen shown by Dr. J. B. S. Jackson before the Boston Society for Medical Improvement, in which the "fracture, commencing at the junction of the head with the upper part of the neck" of the right femur, "extended to within about the fourth of an inch, or a little more, of the periosteal surface of its inferior and internal wall. * * * * The patient, a healthy man of forty-two years, fell through two stories of a building upon a hard floor, fracturing his backbone and the middle third of the shaft of the right thigh-bone, nearly in a transverse direction, complicated with another fracture extending upward from this, splintering the bone for several inches." In the outline sketch accompanying the report, the first-named lesion looks very much like an incomplete extra-capsular fracture of the cervix femoris.]

Single complete fractures of this part are themselves extremely rare. The observation of M. Mercier, already quoted, is one instance, and to this should perhaps be added that of Michon; both, which is remarkable, belong to the variety in which the great trochanter forms a part of the upper fragment. But as for what I have called the normal type, I know of but a single case of an almost single fracture, that is to say, one without any other complication than two small fissures of the trochanters.† Others have indeed

* *Archives Gén. de Médecine*, 1837, tome xiv, p. 77. The author adds that the fracture was at once *intra* and *extra-capsular*, but this is not in accordance with his description.

† R. W. Smith, *op. cit.*, obs. 34. [The term *single* is the only word which answers to the French "*simple*" as applied to fractures; its meaning in this use will be readily perceived.]

been cited, but they were in long-standing cases, and sufficient attention was not paid to the condition of the great trochanter.

Multiple fractures are therefore beyond comparison the most common, and present themselves in two principal varieties. In the first, the great trochanter is broken off by itself at the same time with the cervix, and constitutes a third fragment; in the other the lesser trochanter is likewise separated, forming a fourth fragment. Then there are cases in which the third fragment is formed by the lesser trochanter, the greater forming part of the upper piece, (Guthrie;) others in which both trochanters are found connected with the same piece, as in the specimen represented in *Fig.* 71; and others again, in which the great trochanter is splintered or crushed. But these different circumstances have only a secondary interest, and are subordinate to the two chief complications, fracture of the greater trochanter by itself, which is the most common, and double fracture involving both trochanters.

Lastly, the difference of aspect between recent and long-standing fractures has misled R. W. Smith into distinguishing between ordinary extra-capsular fractures and such as are attended with penetration, or impacted. I assert, on the contrary, that all fractures in which the cervix femoris is detached at its base are impacted; and that this impaction is entirely wanting only in those exceptional cases in which the great trochanter forms part of the upper fragment.

Fig. 68 affords an example of extra-capsular fracture, with the trochanter broken off also; the bone is seen from behind, and the fragments drawn as in their natural position, in order better to show the direction of the double fracture. Nothing, either in the drawing or in the dried specimen, in which all the fragments are loose and disunited, indicates any penetration; but in the subject, the head of the femur was strongly inclined inward; all the lower part of the neck seen outside the capsule was buried in the thickness of the lower fragment, the cutting edge of which had stripped up and turned inward the periosteum, and in *Fig.* 69 are seen two isolated bits of the spongy tissue crushed by this penetration; lastly, the great trochanter, involved in the inclination of the head of the bone, was itself drawn strongly inward, lying as it were upon the top of the shaft. Had consolidation occurred, we should have had very nearly the result represented in *Fig.* 70: the head inclined downward; the great trochanter laid upon the summit of the shaft, in such a way that its inner face is in the same vertical line with the inner face of the shaft, and lastly the inferior wall of the cervix buried in the thickness of the lower fragment.

But the penetration itself presents some variations which it will be well to note. In general it occurs only below and behind, the fragments even remaining a little separated in front; then the lower fragment, consisting of the diaphysis, always projects more or less

in front of the upper, and the result is that the head and neck of the bone are not only inclined downward, but backward also. Sometimes the penetration takes place directly and *en masse*, the anterior wall of the cervix being engaged as well as the posterior; we even see some very rare cases in which the superior wall seems also to share in it, when the head is inclined neither backward nor downward; at least its inclination is reduced to almost nothing. Lastly, the penetration may amount to only a few millimètres, or it may involve almost the whole lower wall of the cervix; in *Fig.* 71 the latter is nearly in contact with the outer wall of the diaphysis. It has even been stated that sometimes *the base of the cervix pierces through the trochanter, coming out below the bursa lining the tendon of the gluteus maximus, after having caused a comminuted fracture of the above-named process;** but this results from a misinterpretation of facts. In the only case in which R. W. Smith has observed anything similar to this, it is evident from the drawing that there is merely an exposure of a very small portion of the cervix, behind and not outward, by the displacement of the trochanteric fragment.

Extra-capsular fractures are less common than intra-capsular; but like them they are more frequently met with in women than in men, and especially affect persons over fifty years of age. Of seventeen extra-capsular fractures in the Richmond Hospital Museum, the histories of which are known, nine were in women; only one was taken from a person less than fifty years old. *Figs.* 68 and 70 represent specimens from men of fifty-four and eighty-seven years respectively; I am not informed on this point concerning *Fig.* 71.

The most common determining cause is a fall upon the great trochanter, either from a great height or with great violence, whether from the standing position or from off a chair. Next come blows on the same process, which however are much more rare; thus Desault saw a case in which the cause was the kick of a horse. Direct blows are on the contrary the best, and perhaps the only means of producing this fracture in the dead body; M. Rodet has even attempted to establish an exact correlation between this species of cause and this species of fracture. I have shown when speaking of intra-capsular fractures that this theory was too absolute; and we have just seen that in M. Tournel's case of incomplete fracture the cause was a fall on the buttocks. But the case which most directly contradicts the theory in question is that communicated by Powell to Sir A. Cooper; a woman eighty-three years of age was walking in her chamber, came near losing her balance, made an effort to save herself, and in consequence of this effort, without any fall, had an extra-capsular fracture. It would be difficult in this case not to re-

* Robert, *Mém. sur les fract. du col du fémur, accomp. de pénétration; Rapport à l'Acad. de Médecine; Bulletin de l'Académie*, tome x, p. 322.

cognise muscular action; it shows, moreover, from what slight causes the fracture may sometimes result.

How do these determining causes act? The idea which first presents itself, and which has misled many authors, is that the external violence tends to obliterate the angle between the neck and shaft of the bone, the lesion thus commencing in the lowest of the bony fibres. Pathological anatomy completely refutes this hypothesis. In the only case of partial fracture known to us, the lowest fibres were the only ones uninjured; in nearly all complete fractures the penetration is greatest below, showing that the force has acted rather so as to diminish than so as to increase the angle; and in no case has the angle been seen to be increased in any way whatever. In some instances there seems to have been direct crushing; but in a good many others, the separation anteriorly seems to denote that the force has acted by impelling the great trochanter backward. I have shown in connection with intra-capsular fractures that this latter is the appropriate result of falls on the side, on account of the natural inclination of the process alluded to; M. Robert has found an additional reason in its anatomical arrangement. The neck of the bone is almost directly continuous, anteriorly, with this process; while posteriorly it is separated from it by a much deeper depression. The axis of the neck therefore answers only to the anterior third of the trochanter, and a fall directly upon this process would necessarily drive it farther backward, when it is unsupported, thus making the two fragments form an angle salient forward.

The symptoms as stated by authors are nearly the same as those of intra-capsular fracture: pain, swelling, loss of power in the limb, shortening, eversion of the foot, and crepitation. Let us examine these in order.

(1.) The *pain*, according to Sir A. Cooper, is severer than in intra-capsular fracture; I think I have reduced this assertion to its proper value. M. Robert has added, with more truth, that it is more external, and that in fact pressure upon the great trochanter acts directly upon the fracture; but unfortunately this pressure likewise occasions pain in the intra-capsular variety.

(2.) The *swelling* is generally more marked than in intra-capsular fracture, and is moreover frequently combined with ecchymosis at the outer portion of the hip and of the thigh. It is important to note, however, that cases are not very rare in which there is no ecchymosis.

(3.) The *loss of power in the limb* is less, according to M. Robert, than in intra-capsular fracture, and the impaction allows the patient to raise the whole limb, and even to walk immediately after receiving the injury. Sir Astley Cooper, on the contrary, asserts that the abnormal rigidity of the joint, due to the pain, hinders flexion and extension. These different phenomena will indeed present themselves

in different cases, and even succeed one another in the same case; but I have shown that this is true also of the intra-capsular form, and M. Robert himself has quite recently presented an exemplification of this to the *Société de Chirurgie.*

(4.) *Shortening* would seem to be a constant phenomenon in this lesion, but it occurs in very various degrees, by reason chiefly of the mechanism to which it is due.

When the trochanter forms a portion of the upper fragment, this rides up outward so as to lessen the angle between the shaft and the neck of the bone; all the shortening depends upon this movement, by which the head of the bone is tilted downward. If the fracture is a single one, it cannot amount to much; but it increases in proportion to the number of splinters. Guthrie has found it half an inch; M. Nivet has estimated it at eight or ten lines; R. W. Smith at an inch and a half, but he probably confounded somewhat the real shortening and the apparent.

In ordinary fractures, as has been stated, the inner fragment is sometimes driven directly into the outer one; the shortening, depending solely on the degree of this penetration, is then always very limited. R. W. Smith has described and figured a case of this kind in which it amounted to only a quarter of an inch. In an analogous specimen, No. 166 in the Musée Dupuytren, the head seems at first sight to have maintained its usual level; but on measuring the vertical distance between its level and that of the base of the great trochanter, this is found to be but an inch and three-fifths, from which may be inferred a shortening of one-third to one-half an inch.

But most commonly the shortening is due to the combination of these two elements, the tilting of the head and the penetration of the cervix; varying according to the degree of each. The former especially is only limited by the lower edge of the fracture, preventing the neck from descending any farther. When the lesser trochanter remains intact, it affords a *point d'appui* to the cervix, just as it does to the head in intra-capsular fracture. But in order to rightly estimate the shortening thus produced, it must not be forgotten that the head of the femur is normally more or less elevated above the trochanter in different subjects, and especially at different periods of life. Thus in both *Figs.* 68 and 70 the neck has been arrested by the lesser trochanter. But in the former case the patient was eighty-seven years old, and the head was above the trochanter by only one-third of an inch; the actual shortening was only half an inch. In the latter the age of the patient was fifty-four at the time of the injury, and seventy at the time of his death; the shortening amounted to a full inch.

When lastly the lesser trochanter is itself detached, the head of the bone, being no longer arrested by it, descends much farther, even to the extreme limits of the fracture. In the specimen represented

in *Fig.* 71, a large fragment comprising both trochanters was broken off, and carried backward and downward; the cervix is seen to have descended until it brought up against the anterior wall of the shaft; and the actual shortening could not have been less than one and a half to two inches.

Hence we see the incorrectness of Sir A. Cooper's assertion, that the shortening does not exceed three-quarters of an inch. M. Bonnet has verified by dissection shortenings of an inch to an inch and a half, and R. W. Smith saw them as great as an inch and a half to two inches.

A more difficult question is whether in these fractures the shortening is always the same. In Sabatier's first observation, which seems to have been a case of extra-capsular fracture, it is stated that there was no shortening until several days after the fracture. It may readily be conceived that any accidental movement, or even mere muscular contraction, would suffice to increase the tilting of the head of the bone, and with it the shortening; but this could not then take place to any great degree, and in order that Sabatier's case should have its full weight he should have made the nice distinction between real and apparent shortening.

(5.) The *eversion of the foot* in these cases is explained by the impaction of the posterior wall of the inner fragment, which is assuredly due to the direction of the external violence; a fall on the trochanter while the foot was inverted, would in the same way give rise to the opposite condition. Often this distortion is so marked that it cannot be corrected, and the foot restored to its normal position, without using a considerable degree of force; but sometimes the limb obeys the slightest manipulation. The subject of *Fig.* 68 had the foot turned outward, but it could be easily rotated inward, and on the other hand in one of R. W. Smith's cases the foot was turned inward, but could with equal facility be rotated outward.

All this has reference to ordinary cases; but when the greater trochanter forms a part of the upper fragment, Guthrie has imagined that *in*version was unavoidable, seeing that the majority of the external rotator muscles, the pyramidalis, the gemelli, and the obturatores, being all inserted into the digital fossa of the great trochanter, act only on the upper fragment, while the gluteus medius and minimus, rotating the limb inward, act as much as ever upon the lower one. It is certainly true that in the three cases cited by Guthrie, M. Mercier and M. Michon, the foot was inverted; but in those of M. Nivet and of R. W. Smith, it was turned outward, notwithstanding the theory.

(6.) The *crepitation* is sometimes very striking; at other times it is entirely wanting, in spite of all our efforts to elicit it; such was the case in the subject of *Fig.* 68. R. W. Smith gives this difficulty of obtaining crepitation as a chief symptom of fractures with pene-

tration, forgetting that it has been as clearly pointed out in the intra-capsular variety.

To these symptoms, admitted by all surgeons, others of more doubtful value have been added. Brunninghausen teaches that there is abnormal mobility of the great trochanter; Desault adds that it can be felt to turn on itself as on a pivot, when the thigh is rotated; and Bichat takes care to state that this sign is more perceptible when the fracture is at the base of the cervix. I have myself never met with it; I have been rather inclined to think, as I shall presently mention, that the trochanter described in the rotation of the bone a larger arc of a circle than it would when uninjured.

R. W. Smith, again, thinks that an essential symptom of impacted fracture should be the difficulty of restoring the limb to its natural length. He has deduced this from the appearance of fractures of long standing, and in process of consolidation; but in a recent case the penetration will always yield to a tractile force of about forty pounds. The general law in regard to extension must also be borne in mind, that it is easy on the first day, but becomes difficult as soon as inflammation is set up in the muscles around the seat of injury.

Lastly, M. Robert has pointed out *the swelling of the greater trochanter, constant when the neck is driven in among the fragments of that process, but due to the engorgement of the soft parts when it is not broken.* According to this, the symptom in question would be met with in a mere contusion of the hip.

But there are other much more practical symptoms, furnished by the almost constant fracture of the trochanter, and by its various displacements. It is most generally tilted inward, as is seen in *Figs.* 70 and 71; so that its external surface becomes superior, and its superior border internal. It seems then flattened and as it were crushed, and hence notably diminished in height. Thus its appreciable height from base to summit varies from an inch and one-third to an inch and two-thirds in the femur of an old person; a comparison of *Figs.* 68 and 70 will show how much this is diminished in case of fracture. From this we see that if we measure the trochanter from base to summit, or even the whole femur from the condyle to the top of the trochanter, we find a notable degree of shortening on the side of the fracture; and that if we examine whether or not the trochanter is drawn up toward the crista ilii, a measurement from the base of the process will show that it is so, while one taken from its summit will present no great difference between the two sides.

Besides this flattening, the trochanter sometimes undergoes another displacement backward, toward the sciatic notch, where it forms a prominence resembling the luxated head of the femur; and when the foot is at the same time inverted, the differential diagnosis becomes quite difficult. I have seen one example of this in the living

subject, and only perceived my error when a very manifest crepitation was elicited by my first attempts at reduction. I have observed a similar prominence, the foot being everted; and although the fracture was evident, I was at a loss to account for this phenomenon. Stanley alone, so far as I know, has clearly demonstrated by dissection the nature of the lesion. He ascertained, in one case of fracture of ten days' standing, that it was a portion of the trochanter which had been thus thrown backward, only maintaining some connection with the shaft by means of the periosteum. In another case, the injury had occurred three years previously, and had always been doubtful in its nature; it was the posterior and larger portion of the trochanter which had been carried backward, and which, in spite of its distance from the shaft, had at length become reunited to it.*

The trochanteric fragment is sometimes also carried upward and forward; Desault met with an instance of this, in which the broken piece was isolated, and could be moved in any direction, the shaft remaining at rest.

And lastly, when this fragment is tilted inward, it pushes the upper part of the neck in the same direction, (see *Figs.* 70 and 71;) and in spite of the penetration of the lower portion, it is certain that the distance of the head of the femur from the base of the trochanter is augmented; that the trochanter thus makes a more considerable prominence outward than normally, and that it describes, when the thigh is rotated, a larger arc. I have made a comparative measurement of the distance from the head to the trochanter in the case represented in *Fig.* 68; it was increased by one-third of an inch. This direct comparison I could not institute in the two other specimens; but the same space in a healthy femur amounted to ninety-one millimètres, [three and one-thirtieth inches;] now in the specimen from which *Fig.* 71 is taken, in which the head is somewhat flattened as the result of senile changes, it is ninety-seven millimètres, [three and one-quarter inches,] and in that represented in *Fig.* 70 it is as much as eleven centimètres, [three and two-thirds inches.]

The course of these fractures is very simple; bony union is in them the rule, its deficiency the exception. The callus forms, as in all fractures of the cancellous extremities of the bones, by the addition of a little ossific matter on the outside, to fill up the angles or gaps left between the fragments, and by the complete fusion of the spongy texture within. Thus in *Figs.* 70 and 71, no other trace of callus is seen than the compact line showing the penetration of the lower portion of the cervix. The callus is also formed very rapidly, except in case of very great alteration of the bony structure. Desault fixed forty days as the term required for consolidation; in one

* Stanley, *Medico-Chir. Transactions*, vol. xiii, p. 504.

instance he made an autopsy on a woman seventy-one years of age, at the forty-ninth day, and found a very firm callus. The subject of *Fig.* 70 had worn no apparatus after the forty-eighth day; but assuredly the union was not wanting in solidity.

The consequences depend therefore solely on the amount of shortening. In the patient mentioned, whose shortening really amounted to one inch, the halt was very marked; extension and adduction were free, flexion was almost complete; still, to equal these motions on the sound side, the pelvis moved a little on the last lumbar vertebra; abduction alone was extremely limited. But in a man of seventy-four, who had by measurement no more than one-third of an inch shortening, the motions were almost perfectly restored in less than three months; they evidently took place in the joint itself, and the patient could walk a league without a stick. The difference in the two cases, in regard to abduction, is readily explained by the different degrees of inclination of the head of the bone; in *Fig.* 70, in which it is very much depressed, we see that upon the slightest attempt at motion outward, the neck of the femur would strike against the edge of the cotyloid cavity. But all cases do not terminate so successfully. Thus there has been seen, even when union had occurred between the fragments, an excessive formation of callus, more or less hindering the motions; in Powell's case, two bony prolongations sprang from the summits of the two trochanters, like buttresses, bearing against the edges of the acetabulum. When consolidation does not occur, the deposition of bone is sometimes almost beyond conception; I have a preparation in which the upper extremity of the femur is buried, so to speak, in a mass of callus not less than twelve inches in circumference. M. Manzini has presented a very similar specimen to the *Société Médicale d'Emulation.**

Lastly, extra-capsular fracture, like the other variety, may involve much more serious dangers; too often, whether from the shock occasioned by the external violence, or from some unfortunate predisposition of the patient, there ensues nervous delirium, or intense fever of the adynamic type, which sooner or later terminates fatally. Sir A. Cooper even makes this a symptom peculiar to extra-capsular fractures, an idea which cannot be maintained, although they are perhaps somewhat more liable to its occurrence than the others. Of the eighteen extra-capsular fractures preserved in the Richmond Hospital Museum, nine proved fatal between the fifth and the fifteenth day.

This first danger being past, there may still ensue others, owing either to the patient's cachectic condition, or to some impropriety in

* Manzini, *Thèse inaug.*, Paris, Aug. 16, 1841. M. Manzini gives at the end of his thesis a short description of my specimen, as well as of another, which I mentioned in connection with intra-capsular fractures, and which was given me by M. Teissier.

the treatment. The pain about the seat of the injury persists; œdematous swelling of the affected limb, and sometimes even of the sound one, occurs; a slow fever undermines the strength, impairs the appetite, and disturbs the sleep; and in hospitals there appear occasionally also symptoms of scurvy. Sabatier says that he thus lost several patients by scorbutic wasting, at the infirmary of the Invalides; the subject of *Fig.* 68 died at the end of three months, with the symptoms of scurvy very plainly developed. It is in these cases, in which the constitution is entirely broken, that sloughing occurs over the sacrum; mere confinement could not bring it on. Upon dissection we find bloody or purulent effusions around the fracture, and in the joints; sometimes chronic phlebitis, with obliteration of the venous trunks coming from the lower extremities; and often the fracture is no more united than it was on the first day. Thus the fracture represented in *Fig.* 68, dating back more than three months, presents all the characters of a recent injury, except that the edges of the fragments are slightly worn.

These consequences are common to all fractures of the cervix femoris. Wishing to ascertain the mortality from them in our large hospitals, I have consulted the tables obtained from the Hôtel-Dieu.

Of the 105 patients received, ten went out before the fifteenth day; these I have deducted. Of the remaining ninety-five, thirty, or nearly one-third, died. Fortunately, the dates of the deaths diminish the fearfulness of this proportion. Thus:

3	occurred	on the same day as the accident;						
4	"	from the	4th	to the	6th	day after the accident;		
2	"	"	9th	"	12th	"	"	
7	"	"	21st	"	37th	"	"	
5	"	"	45th	"	60th	"	"	
9	"	"	70th	"	187th	"	"	

The three deaths which occurred within the first twenty-four hours, were certainly independent of the fracture; and we may likewise exclude, if I mistake not, many of those which were postponed till after the forty-fifth day. The mortality is still terrible; but the line of treatment pursued had certainly a great deal to do with it, and for my own part, I have been far more fortunate.

Has the age or sex of the patients any influence on the mortality? Among the women, there were fourteen deaths out of forty-nine fractures; among the men, sixteen out of forty-six; they were nearly equal in respect to the period of their occurrence after the receipt of the injury. As to the ages, we find:

Under 50 years	- - - - -	11	fractures,	2	deaths.
From 50 to 60 years	- - - - -	15	"	7	"
" 60 to 70 "	- - - - -	38	"	12	"
" 70 to 80 "	- - - - -	27	"	6	"
" 80 to 90 "	- - - - -	4	"	3	"

Thus below the age of fifty the danger is less; beyond eighty it becomes extreme. But a very unexpected result, and one which needs to be verified by further research, is that the mortality is greater between fifty and sixty than between sixty and seventy, and especially than between seventy and eighty.

The diagnosis presents serious difficulties. When there is no shortening, eversion of the foot, or crepitation, it is hardly possible to distinguish a fracture of the cervix from a mere contusion of the hip. By forcibly turning the foot outward, as advised by M. Gerdy, we can doubtless lessen the obscurity of the diagnosis; but by so doing we should risk the production of displacement, and the rupture of the fibrous tissues connecting the two fragments anteriorly; so that this means should be tried only with great caution.

If the surgeon trusts to his eye as a test of the shortening, he will be liable to mistake for reality the apparent shortening which exists in the majority of lesions of the hip; and if crepitation be added to this, he may be in doubt between a double vertical fracture of the pelvis and a fracture of the acetabulum. Methodical measurement will show him in the first place whether the iliac spine has itself been carried upward, which besides crepitation is the only means of detecting double vertical fracture of the pelvis; and fracture of the acetabulum only causes shortening when it is attended with dislocation, as will be mentioned hereafter.

There are some extra-capsular fractures with displacement of the trochanteric fragment backward and rotation of the foot inward, which simulate luxation upward and outward. Here we must seek if possible to elicit crepitation; if this cannot be done, we must try to overcome the projection by means of strong tractions; or we may attempt to evert the foot, which luxation does not admit of, but which we can generally do in cases of fracture.

Lastly, I have already alluded to a peculiar affection which has been more than once taken for fracture of the cervix femoris, even in examinations after death; namely, rachitic degeneration [*ramollissement*] of the head and neck of the bone. Gulliver relates the case of a young soldier of nineteen, who having sustained a fall on his hip, continued to fulfil his duties for three years, and then began to limp; he died eight months afterwards, and the autopsy revealed a flattening of the head of the femur, with shortening of the neck, in the centre of which was a bony induration.* This lesion is more common in advanced life, and it is therefore in old people that the error has been several times committed. Thus in each of the three cases reported by Langstaff, Chorley, and Field, and brought forward again by Amesbury, after a fall upon the trochanter the limb seemed shortened, rotated outward, impaired in its motions; the

* *Gazette Médicale*, 1836, p. 842.

patients were treated for fracture of the neck of the bone; at the end of a certain time they walked, but with more or less of a halt; on dissection several years afterwards, the cervix was found deformed and shortened, and bony union was declared to have occurred. It is to be presumed that in all these cases the apparent shortening was mistaken for real, and the natural rotation of the foot for eversion from injury. We may therefore avoid such errors at the outset, by exactly measuring the shortening, and by ascertaining the degree of eversion with equal accuracy. Still, the diagnosis cannot be in this way placed beyond doubt except in a very recent case; and subsequently, when the disease has actually produced the lowering of the head and shortening of the neck of the femur, I know of no way of distinguishing it from an old fracture.

It remains finally, the fracture being detected, to determine its seat, whether it be within the capsule or outside of it; and this is not the least difficult part of the differential diagnosis.

Sir A. Cooper has attempted to solve the question by arguments drawn from the age of the patient, from the nature and severity of the fracturing cause, from the degree of pain, the amount of shortening, etc. I have shown that several of these signs are absolutely worthless, and that in regard to others Sir Astley's views are contradicted by known facts. R. W. Smith and M. Robert have succeeded no better; and it is impossible, with the so-called signs given us by these three surgeons, to determine the exact seat of the fracture. I have in my turn attempted to compare, in the following table, the most prominent characters of the two lesions.

Intra-Capsular Fractures.	Extra-Capsular Fractures.
(1.) *Recent Cases.*	
A fall on the foot or knee, abducted; a fall on the buttocks.	A direct blow, such as the kick of a horse, on the great trochanter.
Slight swelling; no ecchymosis.	Marked ecchymosis about the hip.
Pain about the insertion of the psoas muscle, radiating sometimes even as far as the knee.	Severe pain on pressure over the great trochanter.
Shortening sometimes absent at first, suddenly coming on after several days or even weeks.	Shortening evident at once, perhaps increasing slightly in a few days.
Shortening not over one inch.	Shortening varying from one-third of an inch to two inches.
Great trochanter intact, and approaching the crista ilii by a distance equal to the shortening.	Great trochanter crushed at its summit, hence less elevated, and hardly approximated to the crista ilii.
Great trochanter apparently obliterated.	Great trochanter more prominent, and describing a larger arc than that on the sound side.
The femur of its normal length between the summit of the trochanter and the external condyle.	The femur seen to be shortened when measured from the external condyle to the summit of the great trochanter.

Intra-Capsular Fractures.	Extra-Capsular Fractures.
Great trochanter never displaced, nor abnormally movable.	The trochanteric fragment sometimes displaced backward or forward, sometimes fixed, simulating the luxated head of the bone; sometimes movable in every direction.

(2.) *Cases of Long Standing.*

Walking long difficult, and even impossible without assistance.	Walking soon becoming firm and steady.
Shortening becoming greater, sometimes even double its original amount.	Shortening hardly augmented at all in some cases, and generally remaining always the same.
Prominence of the trochanter apparently increased, in reality diminished.	Prominence of the trochanter always more marked.
Progressive wasting of the limb.	Nutrition of the limb maintained.
Voluntary motions taking place in the lumbar region, but wanting in the hip-joint.	Voluntary motions executed almost entirely in the hip-joint.

Among the symptoms enumerated in the above table, some furnish mere presumptions, while others afford certainty. Thus actual shortening of the limb, joined with crushing of the trochanter, can only belong to extra-capsular fracture; and the same is true of a shortening of an inch and a half or two inches, coming on immediately. But to give things their true value, we must bear in mind that many fractures of the cervix afford no well-marked characteristics; that the swelling sometimes masks those which are most so, and that even the most methodical measurement does not remove all chances of error. In the case represented in *Fig.* 62, the real shortening was nine-tenths of an inch; but on several occasions during life I had made it out an inch and one-sixth. Our measurements indeed correct the illusion due to lateral inclination of the pelvis; but sometimes there is an inclination of it forward, constituting a new source of error, and one which is less easily avoided. Thus, while as a general rule measurement is worthy of our full confidence, it may occasionally give rise to inexact results; although the amount of error has never within my observation been more than one-third of an inch. The consequence is that we must not believe implicitly in any but marked differences; with an inch and a third shortening, for instance, there is ground for suspecting the case to be one of extra-capsular fracture, but to complete the diagnosis other signs are necessary; while a shortening of an inch and a half or two inches would seem to me to be of itself a pathognomonic symptom.

The gravity of the prognosis depends entirely on the complications, and on the period of life; as for the fracture itself, we may generally promise a successful result, except as regards shortening, which is unavoidable.

The treatment hitherto adopted in fractures judged to be susceptible of consolidation, has been based mainly upon these three indica-

tions: (1) to correct the shortening; (2) to obviate the eversion of the foot; (3) to keep the fragments at rest. Sir A. Cooper has added another,—the pressing of the fragments together, so as to maintain their contact; M. Guyot, on the contrary, thinks it important to protect them from any pressure whatever. All this calls for careful study.

First Indication; to correct the shortening.—This indication presents itself so naturally, and its aim is so apparent, that most surgeons have tried hard to fulfil it. But they have sought to do so by very different methods, which may be arranged under three principal heads.

The first method is by *permanent extension*, made by means of loops, weights, splints more or less complicated, and even with actual machines. I have dwelt sufficiently on these forms of apparatus in speaking of fractures in general, (see *ante*, p. 196;) I have also stated the inconveniences attending their use.

Struck with these disadvantages, Foubert thought to attain the same end by *repeated extensions;* that is to say, the shortening being reproduced very soon after each time it was overcome, he renewed the tractions, at first daily or even every twelve hours, till the twelfth, fifteenth or twentieth day, and afterwards at longer intervals; generally abandoning it after the twenty-fifth day, and then merely keeping the limb confined with the ordinary lateral compresses.*

Subsequently Brunninghausen, after making suitable extension, sought to keep it up by *fastening the two limbs together.* He used for this purpose a roller around the thighs above the knees, and a strong band of muslin to keep the feet together; and lastly, a leather or wooden splint on the outer side of the thigh, fastened by straps to the pelvis and knees. Hagedorn devised a more ingenious apparatus on the same plan. He confined the sound limb by means of straps to a splint, reaching from the hip to the foot, having at its lower extremity, instead of a foot-piece, a wide board; this was pierced with numerous holes for the attachment of bandages, by which both feet were to be immovably fixed to it. The pelvis was also confined to the splint by a broad band. Lastly, Dzondi modified this apparatus, chiefly by prolonging the splint up over the ribs, so as to fix the thorax to it with a strong strap.†

Of these three methods there is one,—that of Foubert,—which is so foreign to all scientific ideas, that it can hardly be conceived of as having been seriously proposed. Such repeated extensions could have no other effect than to torment the patient, for the trifling satisfaction of lessening the apparent shortening; and Sabatier, after

* Sabatier, *Mém. de l'Acad. Royale de Chirurgie*, tome iv, p. 644.

† Brunninghausen, *op. cit.;* Hagedorn, *Abhandl. über den Bruch des Schenkelbeinhalses*, etc., Leipzig, 1808; Dzondi, *Beitrage*, etc., Halle, 1816. The two latter quotations are made from A. L. Richter.

extolling this plan, at length admits that *it cannot prevent the patients from limping more or less, or from having the knee and foot turned somewhat outward;* which is certainly evidence of its perfect uselessness.

The *fastening together of the two limbs* has at least the advantage of insuring the immobility of the fragments; but it is hardly conceivable that any one should expect to overcome real shortening by keeping the feet at the same level, without also firmly confining the pelvis, or consider the pelvis as thus confined merely by a transverse band or strap.

There remains, then, *permanent extension*, properly so called. I shall say nothing of apparatuses constructed of bands, handkerchiefs, or loops of muslin; one needs only to apply Desault's splint once, to be convinced that that celebrated surgeon was completely deceived both as to the value of his apparatus and the reality of his cures. In less than twenty-four hours all the bandages become relaxed, and if we tighten them up every day we are making *repeated* and not *permanent* extension. To combat successfully the constant contraction of the muscles, there is needed a constantly acting force, which can only be obtained by strong leather straps, and a mechanical power greater than the hands of assistants; of all the contrivances for this purpose, that which seems to me the best calculated to produce the desired effect is the mechanical splint of Boyer, in which extension is made by means of a screw. But can even this restore the limb to its normal length? I do not hesitate to affirm the contrary. I have elsewhere given an account of the patient from whom the specimen represented in *Fig.* 70 was derived. He was a man fifty-four years of age; he had been treated with all possible care by a justly celebrated surgeon, who had employed Boyer's apparatus. Extension was kept up steadily until the forty-eighth day, when it had to be abandoned on account of deep ulcerations about the ankle and groin. If we examine the callus, we see that the shortening could hardly have been more considerable if the limb had been left to itself.

I may add that I have never seen, even in Boyer's own patients, the shortening overcome as stated by him; and that, like Desault, he was deceived for the want of a sufficiently exact method of measurement.

But I go still further; I say that it would be dangerous, in the immense majority of cases, to make complete extension; and that prudence should forbid the surgeon's meddling with a shortening which is only moderate in its degree.

After exposing, with due care, the fracture represented in *Fig.* 68, I tested the effect, in the dead body, of regular traction. The foot was drawn down by an assistant, another holding the pelvis back by means of a handkerchief folded cravatwise and passed between the

thighs, as in the contrivances of Desault, Boyer, and others. The results of the extension seemed to me at first very strange, although in fact, casting aside all preconceived ideas, they were quite simple. In the first place the angle between the cervix and shaft of the bone became inordinately widened, then the cervix was disengaged from the lower fragment, into which it had penetrated, and finally the trochanter was separated from the other two fragments; so that the contact and the normal relations of the three were destroyed, and consolidation would have been utterly impossible. Let any one repeat this experiment on a recent fracture, and I will answer for it he will never wish to try it in the living subject.

Hence, except in case the shortening is extreme, unless for instance it exceeds an inch, it is useless and dangerous to try to combat it; and the only rational indication is to try to prevent its subsequent increase.

Second Indication; to correct rotation outward.—We generally limit ourselves, in this respect, to bringing the foot nearly into its normal position, and in a very large number of cases this is sufficient; but sometimes the fragments are not restored by this movement, as can be seen, first from the fact that the foot is not entirely vertical in its direction, and again from the hollow behind the trochanter not being re-established. Hence it happens that when the apparatus is left off, after consolidation has occurred, the foot falls out again more than it should, and its rotation inward is impossible. We should therefore insure reduction as follows: at the same time that we carry the foot inward, we should raise the trochanter and depress the middle portion of the cervix, so as to restore the hollow alluded to.

Retention may be accomplished by various means. Sometimes the foot is attached to a sole, or to a board made fast in some way; sometimes the two feet are fastened together. M. Nélaton, admitting no other indication than this latter, makes his entire apparatus consist of two boards at right angles to one another, one being fixed by a bandage on the plantar face of both feet, while the other merely lies horizontally outward, so as to prevent any fresh deviation in this direction.

Third Indication; to keep the fragments at rest.—It is easy to fix the lower fragment, but we have no purchase on the upper one, and can act on it only through the medium of the pelvis. In order, therefore, to fulfil this indication, we must confine both the pelvis and the lower extremity.

Earle [Sir James] was the first who aimed to do this, semiflexing all the articulations by means of the triple inclined plane of his *fracture-bed;* and M. Bonnet, of Lyons, used for the same purpose his large cuirass, embracing the trunk and the limb in the extended position. There is certainly no objection to either of these contrivances, except perhaps their complexity, and the difficulty of always obtain-

ing them. But if their utility is demonstrated, their necessity is not; and this is enough to exclude them forever from ordinary practice.

Other surgeons, going to the opposite extreme, and pushing simplicity to excess, have almost abandoned the limb to itself. Thus Dupuytren arranged under the ham a sufficient number of pillows to keep the thigh nearly at a right angle with the trunk, and the leg nearly at a right angle with the thigh; the thigh and leg being kept in place merely by two cloths folded cravatwise, passed across over them, and tied to the frame of the bed on each side. M. Nélaton prefers the extended position; but as has been stated, he lets the limb lie upon the bed, with no other apparatus than the foot-piece to hinder rotation outward. Doubtless, satisfactory results have been obtained in cases so treated, but more by chance than by prudent attention; and Dupuytren's apparatus, for example, is perhaps the one most favorable to shortening and deviation of the limb.

The *juste milieu*, which seems to me far preferable, is attained by those who first fix the lower extremity firmly, and then seek to give the pelvis such stability that the process of consolidation may not be hindered. Contrivances for making permanent extension; fastening the injured limb to the sound one; compresses or ordinary splints, extended along the entire limb; immovable apparatuses, have been by turns made use of, and lastly the double inclined plane. I find in this latter the double advantage of relaxing the joints and leaving the limb exposed in its whole length; it is therefore the one which I employ in preference.

[In the United States, the extended position is the one which finds most favor, in all cases of extra-capsular fracture of the femur; the mode of treatment will be mentioned in connection with § V, on fractures of the middle third of the bone.]

Fourth Indication; to press the fragments against one another. —Sir. A. Cooper recommends for this purpose a wide leather band buckled around the pelvis, embracing and pressing upon the great trochanter. But I must say I have found no advantage from this plan, while it seems to me to involve numerous inconveniences.

If the trochanter is already inclined inward, pressure can only tilt it farther over; if it has not yet undergone any displacement, pressure would be the surest means of causing it. As to the fracture of the cervix itself, either it is extra-capsular, and the inner fragment, being driven into the substance of the outer one, needs no external pressure; or it is intra-capsular, and the pressure already exerted by the muscles is only too great, since the inner fragment is seen to waste away beneath it. Thus this indication is in every way wanting in foundation.

M. Guyot, reasoning on the contrary from this wasting of the inner fragment, proposed to combat the muscular action, and to keep the trochanter outward; with this view he advised putting a pad

between the thighs, on a level with their lower half, and approximating the two knees by means of a few turns of a bandage.* But without examining into the possibility of obtaining the desired result in this way, I do not see what we have to expect from it in intra-capsular fracture; and in the extra-capsular variety the trochanter is already too much carried outward, and needs no further displacement.

On the whole, therefore, to correct the eversion of the foot, to give the fragments the necessary degree of immobility, and to prevent any increase of the shortening, or even to try to diminish it if it is excessive, must constitute the whole aim of the surgeon. For my own part, I begin by putting the patient on a quite horizontal surface, in order that the weight of the trunk may not push down the pelvis toward the thigh; and with this same object I put also a wide board underneath the mattress, and allow the head to rest only on a bolster or a single pillow. The limb is then placed upon the double inclined plane, which is previously padded; the foot, carefully brought into the vertical position, is fastened to the foot-piece; the pelvis, sliding back by its own weight upon the upper plane, makes continual extension, but gently, without pain or effort, and the thigh is confined to the apparatus by a handkerchief folded cravatwise. This will suffice in ordinary cases, if the patient is tractable; but we may if necessary apply another cravat over the leg, and fasten the pelvis itself by a long sheet, folded, and tied across the bed. Lastly, if the shortening is so great as to require attention, we may arrange another folded sheet so as to draw the axilla up toward the head of the bed, the foot being held down by the foot-piece.

It is not necessary, unless in exceptional cases, to keep the limb in the apparatus for more than forty-five or fifty days; on the one hand, from what has been already stated, any longer retention of it would be useless; on the other, I have elsewhere† shown the serious consequences of too prolonged confinement, to which cause I mainly ascribe the enormous mortality at the Hôtel-Dieu. I would not advise that the patient should be at once allowed to get up; the weight of the body, or even of the limb, is too great for a callus so recently formed. But he may move about in bed, so as to somewhat restore the suppleness of the joints; eight or ten days afterwards he can begin to use crutches, and I have more than once seen a patient in a condition to walk by the seventieth day.

Treatment thus directed has the advantage of answering equally well for fractures within or without the capsule, the differential diagnosis being rendered indispensable only in regard to the prognosis.

* *Gazette Médicale*, 1835, p. 692.

† Malgaigne, *De quelques dangers du trait. ordin. des fr. du col du fémur; Bulletin de Thérapeutique*, Aug., 1841.

Lastly, in those still more doubtful cases, in which we do not know whether there is a fracture or a mere contusion, it is always the best course for us to follow; and by rest on the double inclined plane I have even succeeded in dissipating coxalgic symptoms, traumatic or otherwise, when in an early stage.

§ III.—*Fractures of the Great Trochanter.*

Fracture of the great trochanter by itself, without injury of the cervix femoris, is an extremely rare lesion. Desault and Boyer have spoken of it, but without citing any instances; Sir Astley Cooper has devoted a special article to it, but he confounds it with that variety of fracture of the neck of the bone in which the process in question forms part of the superior fragment. Hitherto, therefore, nothing has been more obscure than its history.

It presents several varieties. Thus the process may be broken, without any rupture of the fibrous tissues covering it; and then the diagnosis is almost impossible; such a case was communicated to Sir A. Cooper by Aston Key, the fracture being only recognised by dissection. Again, the fibrous tissues being divided, the trochanteric fragment is left to the action of the muscles, which draw it upward and backward, or in some exceptional instances forward; Hargrave found a fracture of long standing in the body of an old woman, in which the trochanter had been drawn upward and backward to a distance of an inch and three-quarters from the other fragment. Lastly, the trochanter is sometimes crushed and splintered; Clarke gives a case of this kind.*

This fracture does not seem, like the preceding ones, to affect old persons in preference; Aston Key's patient was a girl of eighteen, and Clarke's a man of thirty-two.

In every case of this injury hitherto published, the cause was a violent fall on the hip. It may however be presumed that a direct blow upon the process would be quite as capable of giving rise to it.

The symptoms vary according to the character of the injury in each instance. In Aston Key's case there was neither contusion nor swelling; the girl got up after her fall and returned to the house, but with much pain and difficulty; in a word, there was nothing to indicate fracture.

In Clarke's case, the hip was the seat of some contusion, and of very considerable swelling; there was quite severe local pain, which however was only slightly increased by pressure; by raising the foot, or rotating it inward, the patient was forced to cry out;

* Hargrave, *Gaz. des Hôpitaux*, March 22, 1842; Clarke, *American Journal of the Med. Sciences*, Nov., 1836, p. 181.

crepitation was entirely wanting. Hargrave, having only discovered his fracture upon the dead body, says merely that before the dissection there was nothing abnormal in the appearance of the limb.

We can readily see how this fracture, even with the most marked displacement, would influence only slightly the functions of the limb, unless by causing pain; and that there are muscles enough still attached to effect rotation inward or outward, although with some difficulty. The local pain and the contusion are indications of but small value, and to establish the diagnosis, displacement or crepitation must be made out. Two instances, one given by Mr. Bransby Cooper and the other by Sir Astley, will show at once the difficulty and the mode of overcoming it.

Mr. Bransby Cooper had already made two careful examinations of his patient, without any result. He conceived the idea of making him stand up; in this position the buttock presented a sort of knotty prominence, apparently constituted by the retracted muscles. The trochanter could not be felt, either at its normal place or anywhere else. The patient was laid upon his back, and the thigh forcibly adducted, while pressure was made over the glutei muscles as if to bring down the detached fragment, when crepitation was distinctly perceived.*

In the other instance, a man fifty-one years old had had a severe fall upon the great trochanter. At first he perceived only the pain and swelling inseparable from a violent contusion, but these were more than usually persistent; on the twenty-fifth day, in moving the limb, one of the surgeons heard crepitation, and drew the attention of another to it. Brodie, being called in, sought for this crepitus at first in vain; but at length he succeeded in eliciting it by making extended movements of rotation, and concluded that the fracture was in the neck of the bone. Sir A. Cooper was in his turn consulted at about the fiftieth day, and putting his hand beneath the trochanter, easily raised it into its natural position; when every one agreed that the fracture *occupied the great trochanter just at its junction with the rest of the bone.* Mr. Harris, who describes the case, considers that at the time of this last examination the fragments were separated by two inches, and thinks that they became so after Brodie's first visit. This circumstance shows unmistakably that the case was one of fracture of the great trochanter merely, since with such an amount of separation there was still no loss of length in the limb.†

Thus the local pain, increased by movements which tend to separate the fragments, such as flexion of the thigh, or its rotation in-

* *L'Expérience*, tome i, p. 505.

† The report of this case has been completely mutilated in the translating into French, and should be read in the original. [I have been unable to find the account in any English work, or I should have transferred it to this note.]

ward; the hindrance of these movements; the crepitation, obtained either by strong rotation, by forcible abduction, or perhaps by a combination of these two manœuvres; and lastly, the examination of the trochanter, which is found to be flattened or deprived of its summit, with the displacement and mobility of the detached portion; these are the data upon which may be founded a positive diagnosis.

I pass over some other symptoms mentioned by Sir Astley Cooper, such as the eversion of the foot and the shortening of the limb; they are of impossible occurrence, and only enter into his description from the fact that he has, as I have stated, confounded two essentially different fractures.

The prognosis is not at all serious when the separation is but slight. Mr. Bransby Cooper states that he obtained a perfect cure in his patient. But a considerable interspace existing between the fragments would hardly permit us to hope for their reunion; it has been seen to be persistent in Hargrave's case; while in that of Sir A. Cooper, after a confinement in bed for over five months, it is stated that great thickening was observed in the parts around the trochanter, and that the hip-joint entirely recovered its functions; but no reference is made to consolidation, which therefore remains at least very doubtful.

The treatment should, in my opinion, consist merely in keeping the limb abducted and rotated outward, with the knee slightly flexed, so as to make the position more comfortable. At the end of forty days motion may be allowed in the limb; for by this time union either will have occurred, or very probably never will occur at all. Mr. B. Cooper put the limb in abduction, and sought to keep up coaptation by means of a bandage; but any bandage would here be not only useless, inasmuch as it could not counteract the muscles of the buttock, but injurious by endangering the still further depression of the trochanteric fragment. Hence I shall not describe the very complicated apparatus employed by Sir A. Cooper; suffice it to say that the patient, thus kept in bed for more than five months, could not bend the knee for two months more, and only regained the use of this joint by dint of great perseverance.

§ IV.—*Fractures just below the Trochanters.*

I give this name, following the example of Sir Astley Cooper, to fractures affecting the femur either immediately below the lesser trochanter, or an inch or two farther down; that is to say, within the upper third of the entire length of the bone.

They would appear not to have been specially pointed out before the time of Fabricius Hildanus, who gives a remarkable instance in point, and who merely says further that it is more difficult to obtain

union without deformity in them than in fractures occurring lower down.* Boyer acknowledges this difficulty, and accounts for it by the fact that nothing hinders the upper fragment from riding forward. Sir A. Cooper carries the idea further; he asserts that the upper fragment is drawn upward and forward by iliacus and psoas, till it forms a right angle with the trunk; giving in illustration a drawing of a fracture of the kind, preserved in the museum of St. Thomas's Hospital. Now all this is more or less inaccurate, and the history of this fracture needs to be stated almost entirely anew.

It must be stated first that it is quite as common as other fractures of the diaphysis. Of twenty-eight fractures of the shaft of the bone, observed during life, I found ten seated in its upper third; and there are seventeen similar preparations in the Musée Dupuytren.

This fracture presents several varieties, according as it is single or multiple, or at a greater or less distance from the trochanters. *Fig.* 72 represents a fracture seated almost immediately below the trochanter minor; the lower fragment has ridden up very much posteriorly, and an enormous bony *stalactite* embraces the under part of the head and neck of the bone. In *Fig.* 73 the injury has taken place a little lower down; the upper fragment is so turned outward as to leave the other by more than one-third of an inch, and the callus must have filled up the interval thus left. *Fig.* 74 shows a double fracture in the upper third of the shaft.

When the fracture is very close to the lesser trochanter, it is quite often comminuted, and combined with extra-capsular fracture of the cervix. A little lower down, it sometimes assumes a serrated form, especially in young subjects; but it is much more commonly found running obliquely. At least eleven of the seventeen specimens in the Musée Dupuytren are of this last variety. This obliquity is extremely variable, and may affect any direction whatever; but the one most generally seen is downward and inward, as in the upper fragment in *Fig.* 74.

This frequency of oblique fractures is dependent on the nature of the determining causes. It is truly remarkable how few of these are direct. Of my ten cases, no less than eight were indirect, arising from falls on the feet, missteps, etc. It is upon this portion of the femur that muscular action seems also to act in preference, when it is sufficiently powerful to break the bone. Poupée-Desportes relates that a little negro twelve or thirteen years old, being attacked with tetanus, had such violent convulsive movements of his lower limbs that the feet *were turned heel-foremost*, and that both femurs were broken *at their necks*, the fragments protruding *at the outer side of the thighs*. Beauchène has given an account of a man thirty-four

* Fabricii Hildani, *Cent.* v, *Obs.* 86.

years of age, who while sliding on the ice felt himself in danger of falling backward, and made a violent effort to keep up; he did not fall, but he heard at the instant a crack high up in the right thigh, which was found to be broken below the trochanters.*

The symptoms are in the first place, as in all fractures of long bones, pain, swelling, loss of power in the limb, preternatural mobility at the seat of injury, and crepitation, in general readily perceived. But the displacements call for special study.

Sometimes the fragments remain interlocked, and no overlapping is possible; but even then it is excessively rare for the bone to maintain its natural direction; the upper fragment is more or less strongly abducted, so as to form with another an obtuse angle salient outwardly. Of this a remarkable instance is afforded in No. 162 in the Musée Dupuytren. By reason of this abduction, the trochanter is placed on a much higher level than the head of the femur; in other words, the latter is strongly inclined downward and inward, and hence results a shortening so marked that we cannot sufficiently wonder that it has attracted so little attention among surgeons.

It is true that when the fragments become disengaged from one another there is necessarily overlapping, and always to a considerable extent; but even then the shortening arising from the angular deformity is as great, or indeed greater, than that caused by the overlapping.

Thus in the specimen from which *Fig.* 72 is taken, the overlapping being one inch, the whole amount of shortening is two inches. In that of *Fig.* 73, the overlapping is not more than one-third of an inch; the total shortening is an inch or more. Lastly, the double fracture shown in *Fig.* 74, with its double overlapping, would have given but an inch of shortening, which is, however, increased to two inches or more. But these are only the simplest cases; in *Fig.* 73, for example, the angle is at least 140°; but if the fracture were left to itself it would lessen to 120°, 100°, or even less. No. 122 in the Musée Dupuytren presents a fracture of the upper third of the femur, with very slight overlapping, and the fragments at an angle of about 85°; the shortening is more than five inches.

To what cause must we ascribe this displacement, so constant and so marked? At the time of my first observations, it seemed to me as though the patient had felt an itching at the inner side of the thigh, and putting the hand to the spot, had pulled the fragments outward. Afterwards, having met with several cases in which such an explanation was inadmissible, I blamed the inner splint and its padding, which by their tendency to push apart the upper portion of the thighs would tend also to push outward the two fragments. The

* Poupée-Desportes, *Hist. des Mal. de Saint Domingue*, p. 171; Beauchène, *Journ. de Méd. de Leroux*, tome xxx, p. 336.

pressure of the counter-extending band in the groin may perhaps also aid in this result when permanent extension is employed. Subsequently, having seen the same angle formed under the use of other apparatuses, I observed that the patient's pelvis sunk into the mattress, thus drawing the head of the femur inward, and leaving the other end of the upper fragment to stick outward. Doubtless each one of these causes has its share in the effect, and it is well that they should be pointed out, that the surgeon may be aware of them, and guard against them as much as possible. But they do not account either for the constancy of the displacement or for its occasional extent. I think then at present that muscular action should be looked upon as the main source of this; the powerful muscles at the inner side of the thigh represent the chord of the arc formed by the neck and shaft of the femur; when this arc is broken, the muscles act by approximating its extremities, meeting with no resistance; on the contrary their action is rather aided by the muscles inserted into the great trochanter, which favor that motion of abduction by which the upper fragment is carried outward, while the lesser secondary causes before alluded to go to increase the general effect.

The angular displacement is therefore the principal phenomenon of these fractures. But what shall we say of the displacement forward described by Boyer and Sir A. Cooper? I must say here that I have never met with it in the degree indicated by them; most generally it is combined with that already discussed, and even then the upper fragment makes a prominence forward of not more than one to two-thirds of an inch. The drawing given by Sir Astley represents a fracture analogous to that in *Fig.* 73; the real displacement is outward; and he was deceived by the circumstance of the lower fragment being involved in the eversion of the foot, whence its anterior surface is brought into relation with the most prominent part of the upper fragment. Upon the living subject such an error could never be possible; and even in dried preparations, it suffices to remark that it is always the outer and not the anterior face of the bone which looks upward, to prove that the displacement is in the direction of abduction.

But this is not all. Not only then is the projection of the upper fragment forward reduced to something very slight, when it does exist, but in a good many cases it is wanting. Of the seventeen specimens in the Musée Dupuytren, there are seven, a very large proportion, in which it is not present. In three of these the fragments, being interlocked, have undergone only angular displacement; in four, the fracture being oblique downward and backward, the lower fragment rides up forward. I have given in my *Anatomie Chirurgicale* the history of a fracture just below the trochanters in a child of seven, with a marked prominence forward of the lower fragment. The specimen represented in *Fig.* 72 presents a singular peculiarity,

which could not be rendered in a drawing; the upper fragment rides in front of the lower; and yet, so far from obeying the muscles which should draw it forward, it is slightly inclined backward, as if to give the most formal contradiction to the theory.

There are besides these several other varieties in the relative positions of the two fragments; the lower one is very often inside, sometimes outside of the other, principally according to the direction of the fracture. The only displacement of this fragment which calls for special attention is its rotation outward, due to the eversion of the foot.

The course of these fractures presents nothing peculiar; they unite as well and as rapidly as those about the middle of the bone; when they are very close to the trochanter the callus is sometimes exuberant, as in *Fig.* 72; but most commonly it is regularly formed. When the two fragments are joined at a very marked angle, besides the limping inevitably caused, the limb is left somewhat feeble; I have elsewhere (p. 264) alluded to a case of fracture of this kind, which after an interval of six or seven years was reproduced by a very trifling fall.

The diagnosis is a matter of little difficulty when the fracture is simple, recent, and at some distance from the trochanters. If it is multiple in form, and very close to the lesser trochanter, and if the lower fragment is strongly drawn up behind the other, as in *Fig.* 72, it will almost certainly be confounded with extra-capsular fracture. The surest evidence in such a case would be derived from the mobility of the lower fragment while the great trochanter is firmly held; and most commonly the angle salient outward will give the surgeon a clue.

The prognosis is quite favorable when the fragments are interlocked; when on the contrary they overlap one another, we must consider shortening as almost inevitable. Sir A. Cooper seems particularly apprehensive of imperfection in the callus. Facts, however, show that false joint is not more commonly met with in the upper than in the lower portion of the femur. Of thirteen cases collected by Norris, seven were situated high up, six lower down; of eight cited by M. Guérétin, three only were in the upper part of the bone.*

The treatment should vary according to the relations of the fragments. If they remain interlocked, which is a favorable circumstance, the chief indication is either to prevent or to correct any angular displacement. When this already exists, it may easily be corrected by causing moderate traction to be made on the pelvis and foot in opposite directions, and pressing with both thumbs upon the salient angle until it disappears. But to maintain the reduction so made is

* Norris, *op. cit.; American Journal of the Med. Sciences,* 1842; Guérétin, *Presse Médicale,* p. 45.

more difficult; permanent extension, when the *point d'appui* is taken in the groin, endangers the further displacement of the fragments, and none of the other modern forms of apparatus satisfy the indication; surgeons have in fact overlooked it. The plan by which I have been most successful is as follows:

I cause the patient to be laid upon a flat bed, with a wide board beneath the mattress, the head moderately raised, the two lower extremities extended and parallel. The knees and feet are bound together with two handkerchiefs folded cravatwise. I then place on the outer side of the broken thigh a wide splint, which should reach beyond the crista ilii above, and as far as the calf of the leg below. A pad, much shorter than this, is put between the splint and the thigh; the upper end of the splint is then drawn toward the crista ilii by means of a handkerchief or a strip of lead-plaster, or still better by a girdle buckled around the pelvis, and its lower end toward the limb by two bands of the same kind, one above and one below the knee. This splint, tightly applied, exerts at the seat of fracture a pressure well calculated to prevent the formation of an angle between the fragments; but it must not be imagined that the putting on of such an apparatus will do everything. In the first place, it is likely to become relaxed, and must be daily examined to insure its remaining firm; besides which we must guard against the unfavorable conditions alluded to, warning the patient of their probability, and if he is intractable, fastening the trunk securely by means of folded sheets; in a word, we must watch him unceasingly; and even with all this, success is very difficult to attain.

Overlapping involves another indication still more difficult of fulfilment. Slight permanent extension is then necessary, either to prevent any increase of the overlapping, or to diminish it as much as possible. If the upper fragment does not make a marked projection forward, I should still prefer the extended position, making extension as usual by the foot, and counter-extension by loops passed beneath the axillæ. In the contrary case I should place the injured limb by itself on a double inclined plane, the flexion however being very slight in degree. In fact, the more the knee is bent, the harder it is to fix the outside splint intended to counteract the angular displacement; which I regard as the great point in all these cases. When the limb is isolated, whether in the flexed or extended position, it is important to insure the position and the immobility of the foot, so as to prevent its eversion and the consequent rotation outward of the lower fragment.

Sir Astley Cooper has recommended quite a different position: he would have the knee well raised on a double inclined plane, and the trunk at the same time supported by cushions at an angle of forty-five degrees, so that the patient would be nearly sitting up. His

aim was to suit the other parts to the position of the upper fragment, which he believed to be strongly raised up forward. I have shown what this pretended displacement amounts to; the indication is purely imaginary.

Lastly, if either of the fragments should make in either direction a prominence requiring to be corrected, this may be done as nearly as possible by means of small splints placed almost directly upon the projecting points and fastened by strips of lead-plaster.

If the outside splint seems insufficient, we may substitute for it the wrought-iron trough of Fabricius Hildanus, or the hollow wooden splint elsewhere described. (See p. 268.)

The apparatus may be removed by the fortieth day in children, by the fiftieth or sixtieth in adults; but it is prudent to make the patient move his limb in bed for about ten days before giving him crutches, and to make him keep to the crutches until we are well assured that consolidation has duly taken place.

§ V.—*Fractures in the Middle Third of the Femur.*

It is to these fractures that nearly all that has been written concerning fractures of the shaft of this bone properly belongs. If I may judge however from my limited number of observations, they are not more common than the preceding variety, since they constitute only eight in my total of twenty-eight cases.

They may be single, multiple, or comminuted. If single, they are serrated or oblique; *Figs.* 76 and 77 show a fracture with wide indentations, the two portions firmly interlocked; *Fig.* 75 represents one running obliquely from above downward and from behind forward. It is quite remarkable, but this obliquity downward and forward has seemed to me to occur most commonly in these cases, while in the upper third the obliquity is generally downward and inward.

Multiple fractures are more common in the middle third of the femur than at either of its extremities. They are generally double, or in other words, the shaft is divided into three principal fragments; but the middle one of these rarely comprehends the entire thickness of the bone, being rather a large splinter embracing half or more of it, and ordinarily detached posteriorly; sometimes belonging to both the others, which are then both bevelled off like the reed of a clarionet [*en bec de flute*]; sometimes to only one, and then rather to the inferior, which alone is bevelled off obliquely at the expense of its posterior face. When the middle fragment does involve the whole thickness of the bone, one of the fractures generally is seated in the middle third, and the other in the upper. In the Musée Dupuytren

there is one specimen of triple fracture, which is the only one I know of.

Oblique fracture is less common here than in the upper third, and there is likewise a marked difference in the nature of the determining causes. Thus of my eight cases five were produced directly, three indirectly. I have been unable to find any authentic accounts of fractures of the middle third of the femur due to muscular action.

I shall merely mention the symptoms which are common to this and to all other fractures: pain, loss of power, mobility, crepitation, etc. The study of the displacements is of more importance.

There are in the first place some serrated fractures in which the fragments remain in contact; this fortunate circumstance is observed mainly in children and rachitic persons, but I have seen several instances of it in healthy adults. The fracture then presents itself under three conditions. Sometimes the periosteum is unbroken, and there is no crepitation; the only possible displacement is an angular one, which is quite often wanting, and the injury is recognised by this single sign,—the facility of bending one fragment upon the other. Sometimes again the periosteum may share in the rupture; the fragments may still be end to end, although the serrations may be changed in their relative positions; besides mobility and angular displacement, some crepitation may be perceived. *Figs.* 76 and 77 present a curious example of this variety. Lastly, the two fragments may undergo a lateral displacement in nearly their whole thickness, and yet remain nearly end to end, by reason of the entanglement of the fractured surfaces to a greater or less extent; thus in *Fig.* 75, the fracture being slightly oblique downward and forward, the upper fragment is seen to be carried in front of the lower, and yet caught by its posterior wall against the anterior wall of the latter. There was in this case slight overlapping, the two walls in contact having been broken at different heights; there was also a projection of the upper fragment forward and of the lower one backward; still, this partial entanglement of the two fragments had the effect of greatly reducing the overlapping.

When, finally, the fragments are entirely disengaged from one another, there is an overlapping more or less considerable. The upper fragment then almost always passes in front of the other; it is somewhat displaced thus in *Figs.* 75, 76, and 77; and of fourteen single fractures of the middle third of the femur, in the Musée Dupuytren, it has gone in front in twelve, behind in only one; in the remaining case there was no separation. This is the more remarkable, inasmuch as we see nothing like such constancy in fractures in the upper third. I had at first conceived it to be due to the peculiar obliquity of fractures in the middle portion, but as serrated fractures present the same phenomena, its cause must evidently be sought elsewhere.

With the overlapping and displacement in the direction of the thickness is almost constantly combined angular displacement, the angle generally being salient outward. I have several times seen it directed outward and forward, and once almost entirely forward; in the Musée Dupuytren there is a specimen (No. 123) in which the angle should tend to elevate the head of the bone, and to elongate rather than to shorten the limb; but when it is forward, and especially when it is outward, it becomes a very efficient cause of shortening. The angle is indeed generally less acute, and gives rise to less shortening when in the middle third than when in the upper; although this may, in fractures of the former kind which are not properly attended to, attain nearly the same degree; No. 131 in the Musée Dupuytren presents an angle of 110° to 115°.

Lastly, there is one source of displacement which affects only the lower fragment,—rotation outward arising from eversion of the foot. It may happen here, as in fractures of the neck of the bone, that the rotation takes place inward, the foot being turned in this direction; an instance of this exists in the Musée Dupuytren.

These fractures, when simple and without displacement, unite in forty or fifty days; sometimes they require two or three months, when the fragments overlap one another, being in contact only by their lateral surfaces. When the two ends cannot be made to oppose one another, so as themselves to counteract the muscular contractions, it is impossible to preserve the normal length of the limb, whatever may be the apparatus or method employed. There has been too much discrepancy of opinion among surgeons in regard to this. Hippocrates gives the idea that the shortening can always be obviated; Celsus goes to the opposite extreme, declaring that a thigh once broken must ever remain shorter than its fellow. At a period by no means remote from our own, Desault claimed to cure all fractures without shortening, and his journal contains several such cases. In imitation of him, many surgeons have varied, corrected, and improved apparatuses for permanent extension, and have announced as complete successes from them. I must however state positively that I have never obtained anything of the kind, either with contrivances of my own, or with those of others, or even when I have invited the inventors of such apparatuses to apply them in my wards. I have more than once examined persons said to be cured without any shortening, but always discovered such shortening by careful measurement. The mistake of all those who have thought they had obtained these miraculous cures, was that they never dreamed of comparing the two limbs in regard to their length; I will say, moreover, that they were most commonly ignorant of the proper way to obtain a good and correct measurement. Some have been deceived in another way; they have lighted upon fractures with interlocking, especially in young subjects, and have imagined that they had corrected by

treatment a shortening which never existed. In short, when the fragments remain in contact, or when we can replace them and keep them so by means of their serrations, it is easy to cure a fracture of the femur without shortening; in the absence of these two conditions the thing is simply impossible.

Several distinguished surgeons of the present day, recognising this impossibility, have abandoned the idea of permanent extension. They allege moreover that an overlapping of even as much as an inch is of slight consequence, and involves no limping. I cannot entertain this view. I have seen persons walk very well with one-third of an inch shortening, but with more than this they either limp, or must wear a thick-soled shoe; or possibly their halt is masked by a lateral inclination of the spine. Hence we see how grave a fracture with overlapping must always be, and what caution we should observe in giving a prognosis.

The diagnosis is very simple as regards the mere solution of continuity. The difficulty in the great majority of cases lies in the differential diagnosis between the serrated, oblique, multiple and comminuted varieties; we may generally suspect an oblique fracture after indirect violence, a serrated one after direct; but we have no certainty in regard to this except when the fragments remain interlocked. A not less essential element is the appreciation of the different displacements, which is more difficult than might be supposed; sometimes in very muscular thighs, or in those swelled by inflammation, I have found it impossible at first to discover which of the two fragments was on the inner or outer side, in front or behind; and the degree of overlapping can only be estimated by one who is experienced in measuring limbs. I have described, when speaking of the *Diagnosis of Fractures in general*, the manner of measuring the lower extremity when extended; when it is flexed on the double inclined plane, we may take for our two points the iliac spine and the edge of the outer condyle, always carefully putting the other limb in a precisely similar position.

The prognosis results from what has been above stated, adding also our data as to the relative frequency of pseudarthrosis in the femur, and the influence of the plan of treatment adopted.

The subject of treatment has greatly exercised the ingenuity of surgeons. But as this fracture is in some sort the type of fractures of the long bones, it follows that all that was said in connection with the general subject of their treatment is especially applicable here, and that there is hardly anything to be added to it.

Thus, reduction is to be made according to the general rules. I would only observe that having recently had to treat two fractures which had just been sustained, I was surprised at the ease with which a single assistant restored the normal length of the limb; a circumstance which I observed also in the course of my experiments upon

animals. Hence we see the great advantage of promptness, every hour lost adding to the obstacles to be overcome. For the rest, our aim should be to bring the fragments end to end, as in *Figs.* 76 and 77; if, after sufficient traction and proper coaptation, they slip and overlap afresh, we may presume that the fracture is oblique or comminuted, and that reduction is impossible.

To maintain the fragments in contact, every position and all kinds of apparatus have been made use of. Thus there have been tried successively:

(1.) *Simple extension of the limb*, adopted, in the origin of our art, by Hippocrates, and preferred by many surgeons even at the present day.

(2.) *Complete flexion of the limb*, recommended by Albucasis, who by approximating the heel to the buttock made the leg act as a sort of posterior splint. My experiments on the dead body have by no means led me to look favorably on this method, which does not appear to have ever been employed by any one but its inventor.

(3.) *Semiflexion, the patient lying on his side;* extolled by Pott, but now justly abandoned.

(4.) *Semiflexion, the patient lying on his back,* and the double inclined plane, or a mechanical bed, being used.

(5.) *Permanent extension*, with the limb either extended or flexed, and the patient lying on his back.

The choice of a posture has been already discussed in the article on the position to be given to the limb. In regard to keeping the fragments in place, the indications vary in different cases.

In a simple fracture, without displacement, we may take our choice between flexion and extension, as well as between splints, cushions, pads, the immovable apparatus or the double inclined plane.

A description of M. Velpeau's plan will suffice for all those which are based upon the principle of immobility. His apparatus consists essentially of a long roller soaked in dextrine, and three wide pasteboard splints. One assistant holding the pelvis, and another raising the foot, the surgeon first surrounds the limb in its entire length with a dry roller; afterwards he applies over this a single layer of the dextrinated bandage, reaching from the toes to the very root of the thigh. Over this first layer are placed the pasteboard splints, one in front, another behind, and the third on the outer side; the first two extend the whole length of the limb, and the last passes up even to the external iliac fossa. These are kept in place by means of two more layers of the roller, carried up as high as possible over the hip, and made to surround the pelvis several times in the form of a spica.* To insure the extension of the limb during the period necessary for

* Velpeau, *Leçons Orales*, tome ii, p. 552, 1841. In his *Médecine Opératoire*, published in 1839, this author recommended two splints reaching down only to the knee.

consolidation, the middle of a piece of strong bandage is put over the instep, and its two ends fastened at the foot of the bed, while another such strip is passed under the thigh, and its ends tied to the post at the head of the bed. When the bandage is thoroughly dry, these two bands are removed as useless.

The use of splints has the advantage of greater simplicity, as well as of leaving the limb open to inspection. Two splints are necessary, both extending below the sole of the foot, and passing up, the outer one as far as the crista ilii, and the inner one nearly to the ischium. A splint-cloth is placed under the limb, reaching from the root of the thigh as far down as the heel; in this the splints are wrapped so as to come within two fingers'-breadths of the limb; the interspace on each side is filled up by a bag of oat-bran, of the same length as the splint, and the whole is bound together with five strips of bandage; two for the leg, two for the thigh, and the fifth surrounding only the outer splint and the pelvis.

As to the other forms of apparatus, I shall refer the reader to the article on that subject.

If the fragments, although in contact, show any tendency to form an angle, this must be obviated by means of an outer splint fastened at the knee and at the pelvis, as in fracture just below the trochanters.*

When the fragments, after being separated, are fortunately replaced end to end, it is important to see that they do not again leave one another; I have found nothing so efficient in preventing this as four small splints directly applied, one on each side of the thigh, and secured by two or three strips of lead-plaster.

When complete reduction is found to be impossible, but when nevertheless the fragments are interlocked by some of their serrations, as in *Fig.* 75, the pressure of these *immediate* splints is of still greater value. I even employ them to advantage when the fragments only touch by their lateral surfaces; it is no small matter to prevent too great a projection, and it is still more important, for the rapid and firm development of the callus, to keep the fragments pressed closely against each other; there are in the Musée Dupuytren specimens in which the fragments are so separated that an interspace has had to be filled by the callus, as seen in *Fig.* 73 in a fracture just below the trochanters.

Lastly, when the overlapping has presented insuperable obstacles to reduction, as in cases of oblique, multiple or comminuted fractures, we must resort to permanent extension, not indeed with the unattainable end of restoring the full length of the limb, but to diminish the shortening as much as we can. I usually make this extension by

* [I am informed that in his lectures, M. Malgaigne speaks of having successfully used, in oblique fractures of the femur, the screw apparatus which will be described in connection with fractures of the leg.]

means of the double inclined plane; for those who prefer keeping the limb in the straight position, the simplest method consists in attaching the pelvis to the head of the bed with a folded sheet, and hanging to the loop or gaiter surrounding the ankle a weight, by which continuous traction is exerted, and which may be increased or diminished at pleasure.

In all cases, it is essential for the foot to be fastened in a proper position, to avoid any rotation of the lower fragment either inward or outward. I have pointed out, in my *Anatomie Chirurgicale*, a method of ascertaining that the fragments are in their true direction. The limb resting on an even and solid plane, we should place the great trochanter and the external tuberosity of the femur on the same straight line, which should itself be parallel to the sustaining surface.

Lastly, some surgeons have insisted on the importance of making the pelvis immovable upon the thigh, lest the upper fragment should be drawn out of place. The indication is doubtless a rational one; but experience has shown that it is not a matter of absolute necessity. Without therefore insisting upon it too rigidly, the surgeon will do well to bear it in mind, and especially to call the patient's attention to it.

Consolidation being accomplished, we have to restore the motions of the limb; and this is often a delicate and difficult task; since, whatever care may have been taken to avoid too prolonged a confinement, the knee-joint will be found swelled and stiff. I have elsewhere mentioned this in a general way, and shall consider it specially in the next section.

[The subject of fractures of the thigh has attracted much attention among American surgeons, and various plans and modifications of treatment have been devised by them. The system of permanent extension has found the most general favor in all these; in fact the flexed position is advocated by only two of the leading surgeons in this country.

The basis of nearly all the forms of extending apparatus is the splint of Desault, as modified by Physick and Hutchinson, of Philadelphia. Physick carried the upper end of the outside splint nearly as far up as the axilla, thus bringing the counter-extending band much more nearly into the line of the axis of the limb. Hutchinson fixed a block on the inside of the outer splint, (which was lengthened downward also,) a few inches above its lower end; the thickness of this block was such as to keep the extending band, which ran over its inner surface, in the line of the limb. This band was tied around the end of the long splint, by passing one end of the band through a mortise cut in the splint close to its extremity. The splint-cloth, junk-bags, confining-strips, etc., were of the ordinary well-known form.

The counter-extending or perineal band in common use was devised by Dr. Reynell Coates, and is made of buckskin, stuffed with bran or horsehair, so as to form a sort of thick fillet, with a tape at each end by which to fasten it to the upper end of the long splint. This may be made inextensible by using straps instead of the tapes; and if the patient is intractable and persists in unbuckling the straps, a padlock may be easily put on, as proposed by Dr. J. F. Flagg, of Boston.—The latter end may be answered in another way, proposed by Dr. Neill, of Philadelphia; viz., by passing the tapes of the perineal band through holes cut near the upper end of the long splint, carrying them down along its outer surface, and tying them in a knot with the extending bands, which are brought up from the lower end in the same way. These may be tightened from time to time by twisting them with a small stick, on the principle of the Spanish windlass.—In the New York Hospital it is quite common to use a skein of woollen yarn as a counter-extending band, when the perineum is excoriated or tender.—Dr. David Gilbert, of Philadelphia, was, I believe, the first to publish a plan for making counter-extension by means of adhesive plaster; his paper appeared in the *Am. Journal of the Med. Sciences* for January, 1851. He has since (January, 1858,) presented in the same periodical the history of several cases illustrative of his method, which has not as yet come into general use.—Dr. W. E. Horner, late of the University of Pennsylvania, proposed to moderate the pressure on the perineum by passing the counter-extending band through two strong loops on the outer surface of the inside splint, near its upper end, which was deeply notched; the actual pressure being made by a strip of leather stretched across this notch.—Whatever material may be used, it is of very great importance frequently to examine the state of the skin pressed upon, and by stimulating frictions, *the parts being carefully dried afterwards*, to obviate the occurrence of excoriation as much as possible.

This plan (Desault's, modified by Physick and Hutchinson,) is the one at present in use in the Pennsylvania Hospital; with, however, an important improvement in the manner of making extension, the introduction of which is due either to Dr. S. D. Gross, of Philadelphia, to Dr. Ellerslie Wallace, of the same city, or to Dr. Josiah Crosby, of New Hampshire. Physick had substituted for the figure-of-8 of the ankle, made with a bandage or handkerchief, a gaiter lined with buckskin, laced up in front, and fastened by tapes to the lower end of the long splint. This, however, not only required some skill in the making, but was extremely apt to induce irritation and ulceration of the heel and ankle. It was therefore proposed to employ adhesive plaster in its stead; which may be done as follows:—take a piece of strong adhesive plaster, about two inches wide, and twice as long as from the seat of fracture to a point four inches beyond the

sole of the foot; just at the middle of this, place on the adhesive surface a piece of thin board, three inches square. Now cut a longitudinal slit in the plaster, an inch in length, on each side of this bit of board; let the slits be equidistant from the edges of the strip. A bit of bandage, two or three inches wide and three feet long, is now to be passed through both the slits, its ends coming out one at each side; the piece of wood will thus be between the adhesive strip and the bandage. The limb being laid on a level surface, the toes pointing upward, the two ends of the strip, previously heated and well stretched, are applied one on each side of it; the bit of wood in the middle being about two inches from the sole of the foot, the extremities of the strip will just about reach the seat of fracture. Three circular strips, likewise about two inches wide, may be applied to keep the longitudinal one in place; but they should not entirely surround the limb, lest the return of venous blood be impeded. The bandage runs over the block, to be fastened as in any other apparatus. The object of the piece of board is simply to keep the strips parallel, and prevent their roping. Upon the adhesive plaster so applied, any endurable amount of traction may be made without its giving way; and there is very little danger of excoriation, except just above the malleoli, which should therefore be protected by means of lint, raw cotton, or soap-plaster.—Dr. T. H. Bache of Philadelphia has, as was previously mentioned, (p. 198,) proposed a very ingenious double screw for making extension; one screw plays in a mortise cut near the lower end of the long splint, so as to be readily adapted to the width between the splints, according as the limb concerned is a large or a small one; at its inner end this screw has a ball, pierced so as to carry another screw at right angles to it, by which the extension is to be graduated to the required point. The extending band is fastened to a straight cross-bar, which subtends a semi-elliptical one; this latter is pierced at its middle by the upper end of the longitudinal screw, upon which it revolves freely. By turning the screw, the cross-bar is drawn down, and with it the foot.

In the New York Hospital, each long splint is furnished with a block like that of Hutchinson, but somewhat thicker, which is bored for a longitudinal wooden screw; on the upper end of this screw is a brass hook, around which the extending band passes.

It may be well to mention here another very excellent idea adopted in the same institution, viz., to buckle the upper end of the long splint to the patient's body by means of a broad belt of webbing, instead of the mere strip of bandage so commonly employed.

As regards the filling up of the interspaces between the splints and the limb, many surgeons adhere to the old-fashioned junk-bags; some prefer padding the inner surfaces of the splints. It is necessary, especially when the latter plan is adopted, to apply compresses at different points; and for this purpose the best material we can

use is to be found in scraps of old blanket, which can be folded very smoothly, and which do not, like raw cotton, form lumps here and there, or become sodden with perspiration.

There remain to be noticed several other methods, differing essentially from the foregoing. Dr. William Gibson, now Emeritus Professor of Surgery in the University of Pennsylvania, proposed a very simple apparatus, based upon that of Hagedorn; it consisted of two long splints, reaching up to the axillæ, and connected below by a transverse board to which both feet were fastened. The ends of the long splints were very much narrowed, so as to pass through mortises in the cross-piece, and were fixed at any point by means of pegs driven into them transversely, holes being provided for the purpose. Counter-extension was thus made from the axillæ, and extension by drawing down the foot-piece, to which both feet were made fast. The same surgeon sometimes employed a single inclined plane, upon which both lower extremities were laid, and the feet fastened to an upright board by means of gaiters; the feet being thus fixed, the weight of the body was expected to make both extension and counter-extension.—Dr. Joseph Hartshorne, late of Philadelphia, proposed the following plan, based upon that of Boyer: an outside splint, with a padded, crutch-like head, to reach up into the axilla, and an inside one, with a similar head for the perineum; both these splints extended about eighteen inches beyond the sole of the foot, and were connected below by a firm cross-piece, bored for a wooden screw. This screw had at its upper end another cross-piece, sliding in a mortise in each splint, with a wooden sole to which the foot was to be tied. Counter-extension was made by the crutch-like head of the inside splint, and extension by means of the screw drawing down the foot-piece.—Dr. Henry Hartshorne has recently proposed making counter-extension from the tuber ischii, a thick block, hollowed for its reception, being placed between the upper ends of the two side-splints. He has also suggested a cross-bar placed above the patient's body, about on a line with the umbilicus. (See the *Trans. of the College of Physicians of Philadelphia* for 1855 and 1858.)—Dr. F. H. Hamilton, of Buffalo, in his "*Report on Deformities after Fractures*," presented to the American Medical Association in 1857, gives representations of three forms of splints used by him, but unfortunately without descriptions.—Dr. Dugas, of Georgia, makes his extension by means of a two or three-pound weight hung over a pulley at the foot of the bed, the resistance of the body making the counter-extension; side-splints are also used by him, but merely to keep the limb in line.—Various other appliances, more or less complicated, have been contrived for carrying out the principle of extension; among which may be mentioned those of Bowen, Sanborn, and the Burges; and the wire-cloth splints of Bauer, of New York. Although very good results may undoubtedly be obtained with any

of these forms of apparatus, they are not by any means essential to the panoply of the surgeon; descriptions of them may be found in Sargent's "*Minor Surgery*," in the pamphlet of the Drs. Burge, and in Dr. Hamilton's report, before alluded to.

The flexed position is advocated in the United States chiefly by Dr. Nathan R. Smith, of Baltimore, and by Dr. J. C. Nott, of Mobile.

Dr. Smith's plan for treating fractures of the thigh consists in bandaging the whole limb to an anterior splint, either carved out of wood, or made of wire and bent to suit each case; the position given to the limb is one of moderate flexion, and the idea is to apply the bandage so neatly as to form for it a bed exactly adapted to its normal shape. Extension is made by the suspending cord, counter-extension by the weight of the body; and Dr. S. says that the amount of extending force may be graduated by varying the point of attachment of the cord, so that the latter is more or less oblique in its direction. He claims to have obtained very good practical results from this plan, which is in general use among surgeons in Baltimore.*—Dr. J. C. Nott, of Mobile, uses a double inclined plane and short lateral splints; the limb is bound down by means of straps, with vertical pins to keep it still more firmly in place.

Splints of all kinds are discarded in fractures of the long bones by Dr. Dudley, of Kentucky, a simple roller being considered sufficient to retain the fragments.]

§ VI.—*Fractures of the Femur just above the Condyles.*

I give this name to fractures occurring an inch and a half or two inches above the patella, about three inches above the tuberosities and articular surface; that is, in an adult, somewhere in the lower third of the bone. The diaphysis increases in size in this region so as gradually to acquire a circumference half as large again as that of its middle portion; while the compact walls of the medullary canal diminish in thickness, and the spongy tissue becomes more and more abundant, till at length it entirely constitutes the articulating extremity.

These fractures seem to me to be chiefly produced by direct causes. Thus of nine instances which I observed in the living subject, seven were direct and only two indirect, a very different proportion from that seen in fractures situated higher up. Sir A. Cooper does not, however, admit of any but indirect causes, such as a fall from a height upon the knees or feet. But he adds that he has seen none but very oblique fractures, and these are in fact generally due to indirect violence.

These fractures are almost always single, but for small and insig-

* [For an account of another splint of Dr. Smith's invention, see a note to the article on *Fractures just above the Malleoli*.]

nificant splinters; multiple or comminuted fractures are rarer here than anywhere else. They are most commonly serrated, but their serrations are smaller than those of the body of the bone; they assume a transverse direction, which has even led to the idea that they were fractures *en rave*, [see p. 63.] I have already stated elsewhere that M. Denonvilliers believed that he had found in the Musée Dupuytren four or five examples of exactly transverse fractures of the femur, and all, singularly enough, at the lower third. I have had represented in *Fig.* 85 that one in which there is least ground for doubt; and yet if the very marked obliquity of the upper fragment in front can be attributed to the absorption of its angle, the fractured surface of the lower one, which seems exactly transverse, presents a narrowing laterally which can only be explained by the detachment of a serration or of an oblique splinter.

I would not deny that the spongy tissue very near the condyles may be broken exactly across; I only say that it has not hitherto been observed.

Oblique fractures are more rare; *Fig.* 78 presents an instance of a fracture running downward, outward and a little forward; sometimes again it runs downward and inward, or perhaps downward and forward; and then generally the fragments overlap one another a good deal; but there are cases in which the upper fragment is driven into the spongy tissue of the lower, constituting a fracture with penetration: a very remarkable example of this may be seen in No. 143, in the Musée Dupuytren.

The symptoms are in the first place those of fracture in general. Only when the fracture is very close to the knee, the joint shares in the swelling of the limb, and bloody or serous effusion occurs within the synovial membrane. Sometimes the capsule is broken, and thus there is a communication with the seat of fracture.

There may be no appreciable displacement, in which case crepitation may be also wanting; the same thing may happen when there is impaction; but the shortening, and the projection laterally of one or the other fragment, sufficiently point out the nature of the injury. The fragments commonly slip from one another transversely, sometimes only to a certain extent, but oftenest completely; and then the upper fragment is almost always carried in front of the other, unless when some special obliquity of the fracture gives it a tendency outward or inward.

When the fracture is seated quite low down, the riding forward of the upper fragment has the effect of pushing down the patella, and opposing an almost insurmountable obstacle to its being drawn up. In *Fig.* 85 the marked wasting of the upper fragment is doubtless owing to the pressure of either the patella or its ligament. In the oblique fracture shown in *Fig.* 78 the patella has been pushed down

even as far as the tibia, so as to have quitted the femur, thus undergoing an actual luxation.

Other complications may arise from the overlapping, when the upper fragment is very sharply pointed. Sometimes the capsule is perforated by it, and the joint entered; sometimes it passes outward, piercing the muscles, and reaching or even protruding through the skin.

But what becomes of the lower fragment? According to Boyer, *its upper end is tilted backward into the popliteal space; this displacement*, he adds, *by which the anterior extremity of the condyles is directed upward, making a marked prominence at the upper part of the patella, gives a singular appearance to the knee.* I am sorry to say that this description is wholly imaginary. *Fig.* 78 shows the upper fragment riding forward and outward; and the lower one is not in the slightest degree tilted backward. In *Fig.* 85 the upper fragment rides directly forward, and is even separated by several millimètres from the lower, which however remains parallel to it. I have never seen in the living subject, nor is there in any museum in Paris, a single example of the displacement described by Boyer and by others following him; the lower fragment passes up either directly backward or to one side, and is never tilted over into the ham.

Lastly, we sometimes observe angular displacement outward, but more rarely, and especially in a less degree, than in fractures seated higher up. Rotation by eversion of the foot is common to all cases in which the femur is broken.

The course of these fractures presents no peculiarity, with the exception of the effusion into the joint, which keeps up the swelling of the soft parts often even beyond the period necessary to consolidation. Sometimes on the contrary this engorgement, so close to the articulation, at length causes in it an inflammatory exudation and a true hydarthrosis, even when the knee has escaped the primary contusion; I have twice seen this complication arise in the course of the treatment. But it is mainly when union is complete, and when we have to restore to the limb its natural motions, that we should apprehend the occurrence of hydarthrosis; a somewhat rude motion of the joint may develop it, either in a simple and almost painless form, or with all the pain and swelling of acute arthritis. It therefore takes a longer period for the recovery of free flexion of the knee; and in many cases this is never fully restored.

The diagnosis is sometimes rendered obscure by the extent of the swelling which takes place; but in proportion as this subsides, the characters of the fracture declare themselves in such a way as to leave no room for doubt.

The prognosis is always rendered somewhat grave by the proximity of the joint. It is especially unfavorable when the upper

fragment bears the patella downward, wounding the capsule or the muscles; suppuration may then ensue, and carry off the patient; and the least of the evils to be apprehended is lameness, resulting at once from the shortening of the femur and the stiffness of the knee.

Reduction should be attempted here with so much the more confidence, since the fractured surfaces are broader, and more easily kept in contact. Boyer made traction on the limb in the extended position; Sir A. Cooper advises us to begin by flexing the knee, so as to disengage the upper fragment from the muscles, after which reduction is to be made with the limb straightened out. We may, if necessary, have recourse to this manœuvre, putting the forearm under the ham so as at the same time to make extension; without this the flexion will only increase the overlapping, and still further entangle the bone. We should moreover be called in immediately after the accident, since the swelling which soon ensues constitutes an almost invincible obstacle to our success.

For the retention of the fragments, Boyer recommends the ordinary splints, or, when the fracture is oblique, the apparatus for permanent extension; he also advises putting under the upper part of the ham a compress of linen or of charpie, to obviate the tendency of the lower fragment to tilt backward. We have said that this tendency does not exist, whence of course the indication disappears also. Sir A. Cooper, who has seen none but oblique fractures, recommends in all cases permanent extension with the limb straight.

When the fragments are not very movable, I prefer using the double inclined plane, which by somewhat bending the knee tends to diminish the consecutive stiffening of the joint. But when the fragments change their relations upon the slightest movement, I have more than once seen the weight of the pelvis draw the upper part of the limb inward, thus giving rise to a considerable angular displacement outward; in such cases I resort to the long lateral splints, putting a compress under the ham, not, like Boyer, to counteract an imaginary displacement, but with a view of slightly flexing the knee and obviating stiffness.

In young persons external violence may give rise not to fracture, but to separation of the epiphysis. I have already mentioned elsewhere the unique case observed by M. Coural; the patient was a child of eleven years, whose leg was buried in a hole up to the knee, while his body was thrown forward. What was most remarkable in this case was, that the upper fragment was carried backward; and on proceeding to amputate, which became necessary, the condyles were found in front of the shaft, and so reversed that the articular surface was directed forward.* I do not know that this displacement has been observed in fracture just above the condyles; but it is well that its possibility should be pointed out.

* *Archiv. Gén. de Médecine*, tome ix, p. 267.

§ VII.—*Fractures of one Condyle of the Femur.*

This fracture is very rare, and has hitherto been hardly at all studied. Bichat, who first mentions it, would seem never to have seen it; Sir A. Cooper gives but one instance of it, and that quite imperfectly related; and but one specimen of it exists in the Musée Dupuytren. I have seen it in three cases; and these, with one reported by M. P. Boyer, constitute all the positive data we have concerning this fracture.* [Seven additional cases will be presently alluded to.]

It consists in a nearly vertical division of the bone, striking the articular face near one or the other of the condyles, and directed from before backward, which goes up along the bone, deviating inward or outward according to the condyle affected, and terminating two, three, or even four inches above the joint; the detached fragment forming a sort of pyramid, with the condyle for its base.

The two condyles seem equally liable to be broken off; of the six cases above mentioned, three affected the outer one, and three the inner.

The causes are very variable; sometimes it is the weight of some heavy body coming upon the condyles, sometimes a fall of the patient himself upon the knee in a state of flexion; sometimes again it is difficult to make out the mechanism of the injury; in Sir Astley Cooper's case it was caused by a wheel moving round, in the spokes of which the patient had both his legs entangled.

The first phenomenon is severe pain, which is very soon followed by a considerable effusion in the knee-joint and at the lower portion of the thigh. The lateral mobility of the knee is greater than usual; the broken condyle may be moved by itself when the swelling does not prevent its being grasped, and thus we may pretty certainly elicit crepitation; this is generally perceived also when any motion is impressed on the joint. The excessive swelling may however sometimes hinder its production, and the existence of the fracture can only be suspected from the displacement.

In general, the fractured condyle tends to ride up above the level of the other, and to draw the tibia along with it. If the external condyle is the one concerned, the leg is abducted upon the thigh; if the internal, it is adducted. This displacement is sometimes but slightly marked at first; but if the leg is carried inward or outward it is easily seen to go beyond the natural limits both of its adduction and abduction. In other cases, on the contrary, the displacement is so great that the tibia, in order to follow the fragment, is luxated

* Malgaigne, *Mémoire sur la fracture de l'un des condyles du fémur; Revue Medico-Chirurgicale*, April, 1847.

upon the still sound condyle, which consequently forms an abnormal prominence, on the inside or outside as the case may be; the two condyles are then also separated from one another; between them a wide hollow is perceptible; the knee seems broader, and the patella less prominent, than normal. Lastly, in two cases of fracture of the outer condyle, the leg was very much rotated inward, involving a subluxation of the tibia behind the inner condyle.

The course of these fractures presents no peculiarity but the enormous swelling which sometimes accompanies them; the callus is formed without any difficulty, and as in all fractures of spongy bones, there is no trace of the injury left in the interior. Hence they should require less time for repair than those of the diaphysis, and may be considered as healed at the end of forty days.

[I have in my possession a very perfect cast of a specimen of fracture of the right external condyle, the history of which, however, I do not know. The line of division runs downward and somewhat inward, so as to separate the whole condyle, beginning above about two inches and a half from the articular surface. The patella and inner condyle are a good deal displaced inward, as is shown by the direction of the ligamentum patellæ. The upper end of the fragment must have been plainly perceptible beneath the skin. It seems as if the foot had been everted by its own weight, rotating the tibia and the fragment outward.

In a case which occurred during my residence in the Pennsylvania Hospital, a fracture of the inner condyle of the right femur was diagnosed, in a man who had had his leg crushed by a mass of stone; the main symptom was the abnormal mobility at the point indicated. He died of his other injuries, but no dissection was allowed.

Another instance, in which a scale of bone was separated from the inner condyle, the knee being also dislocated, is reported by Wells. (*Am. Journal of the Med. Sciences*, vol. x, [old series,] p. 25.)

Kirkbride reports in the same journal, (vol. xvi, p. 32,) a case in which the outer condyle was broken by the kick of a horse; there was angular deformity outward, and crepitation could be plainly perceived, but there was not much displacement. Union took place, and in eight or nine weeks the patient got up on crutches. He ultimately became able to flex the knee to a right angle.

Brookes reports (*Braithwaite's Retrospect*, vol. xv, p. 149,) the case of a boy with a compound fracture, from which a piece of the external condyle worked its way out after the lapse of three months and a half. A good recovery ensued.

Dr. Godman, in his American edition of Sir Astley Cooper's "Treatise on Dislocations and Fractures of the Joints," mentions a case of detachment of the outer condyle by a blow with an axe.

In the Report on Deformities after Fractures, by Dr. Hamilton of

Buffalo, a case is mentioned as having occurred to Dr. Crosby of New Hampshire, in which a fragment of the external condyle, as big as a walnut, was removed six months after its detachment by violence. No particulars of the case are given.]

The diagnosis is often obscured by the amount of swelling; and I have given, in speaking of the displacements, the means of forming it with some probability.

The prognosis is rendered grave only by complications, or by irreducible displacement.

With rational treatment, we may hope to restore the limb to its form, and to at least the greater part of its motion.

Sir A. Cooper alone has dwelt upon the treatment. He advises stretching the limb out on a cushion; combating inflammation by means of leeches and evaporating lotions; and as soon as the swelling subsides, surrounding the joint posteriorly and laterally as far round as to the patella with a trough of strong pasteboard, previously softened in warm water so as to take the form of the part. This trough, held in place by a bandage, keeps the two condyles pressed toward one another; and the extended position has the advantage, according to Sir Astley, that the tibia maintains the two condyles on the same plane.

The extended position has however the inconvenience of promoting the stiffening of the joint, which is mainly to be feared in consequence of these fractures. In cases in which the displacement was not very marked, Travers put the limb into semiflexion in a fracture-box; M. Gerdy kept it in the same position by means of cushions, and they would seem to have had no want of success. When the displacement is such that the tibia is subluxated, Sir A. Cooper's apparatus would probably be insufficient.

I have treated a fracture of this kind by very slight flexion, the ham being supported merely by a pad, and the limb fixed in permanent extension, also very slight. If in fracture of the external condyle the leg has a strong tendency toward abduction, a long splint must be placed at the outer side of the limb, so as to bear by its two ends upon the leg and thigh, while its centre, opposite the knee, is separated from it by a certain interval; now a handkerchief folded into a wide cravat is made to embrace the knee, pressing it toward the centre of the splint, and thus obliterating the angle resulting from the abduction of the leg. An improper degree of adduction, in fracture of the inner condyle, should be obviated by a similar splint arranged at the inner side of the limb. The complication of a subluxation would probably require two lateral splints, with two handkerchief-bandages to draw the femur and tibia in opposite directions; I shall recur to this in speaking of luxations.

Sir A. Cooper recommends that in order to avoid anchylosis passive motion should be made use of after the thirty-fifth day. This

seems to me a very judicious plan, provided that the joint is entirely free from inflammatory action.

§ VIII.—*Fractures of both Condyles at once.*

This fracture consists essentially in a vertical or oblique separation of both condyles of the femur, communicating above with a transverse or oblique fracture in the lower third of the bone.

It is more common than the preceding variety. Desault, who first described it, gives several cases; Deguise has published one;* Sir Astley Cooper another; I have myself seen it in three instances, and lastly there are four examples of it in the Musée Dupuytren, two of which, indeed, are from Desault's cabinet. [One very fine specimen of it is in the museum of the University of Pennsylvania.]

The causes are most frequently direct; thus it has been seen resulting from a blow with a heavy beam, from the fall or pressure of a heavy body, as a barrel or a piece of casting, or from the kick of a horse. Sometimes we must ascribe to counter-stroke the upper fracture at least, as in falls upon the knee; but Bichat relates the case of a man who broke the condyles by lighting upon his feet; and here both fractures were equally attributable to counter-stroke.

The symptoms are in the first place mainly those of fracture of one condyle alone; pain, effusion into the joint and into the tissues of the thigh, crepitation when the knee is moved, separation of the condyles, depression of the patella. But to these are joined also all the phenomena of fracture above the condyles; greater mobility above the joint than in the joint itself, and especially a notable degree of shortening of the thigh. It has indeed been stated, and not without probability, that fracture above the condyles may be transverse, and unattended with displacement; but hitherto, when combined with separation of both condyles, it has always been found to be oblique, and attended with more or less overlapping. Other displacements have likewise been observed; thus the shaft may be inclined at an angle with the lower fragments; the foot is sometimes everted, and twists the condyles in the same direction. Lastly, there is one symptom which belongs exclusively to the fracture in question; it is that the two condyles, when the swelling of the soft parts does not prevent our grasping them, are movable upon one another and also upon the shaft of the bone.

The course of these fractures hardly differs at all from that of fracture of either condyle alone; consolidation is in nowise impeded by the lesion of the joint, but the displacements are more marked and less easy of correction.

* *Journal de Chirurgie*, by Desault, tome iv, p. 89.

The diagnosis can present no serious difficulty unless the swelling should be so great as to mask the vertical division of the bone, making that which passes across alone perceptible.

The prognosis is somewhat grave; the patient is in danger, on the one hand of shortening of the limb with a troublesome projection of the upper fragment, and on the other of stiffening of the joint; or the injury may be so severe as to give rise to suppuration, threatening the destruction of life.

As to the treatment, two principal indications were established by Desault: to correct the overlapping, and to bring together the separated condyles. He accomplished the first by means of his splint for permanent extension, and the second by a many-tailed bandage and two long lateral splints. These splints may be very properly replaced by the pasteboard trough of Sir A. Cooper, described in connection with the preceding variety of fracture; and a slight degree of flexion upon a double inclined plane would probably obviate, in part at least, stiffening of the joint.

But the essential point is to make use of careful passive motion from the thirty-fifth or fortieth day. I have seen a patient who was treated by Guerbois on the plan of permanent extension; he had remained in bed five months; it was more than a year before he could leave off his crutches, and after eight years his knee was still swollen, with a flexion of only a few degrees; the shortening was a little over an inch. Another, treated by Sanson with two lateral splints and no permanent extension, had worn the apparatus only fifty-six days; he could bend the knee nearly to a right angle, and in spite of nearly two inches shortening he could walk much better than the patient before mentioned.

In this latter case the tibia was also broken near the knee, but without overlapping; so that the lesion was more serious than usual. I have had to treat a fracture of both condyles of the femur, complicated with fracture of the condyles of the tibia and with a penetrating wound; the patient died on the twelfth day. But what I have to say concerning compound fractures will be more in place in the succeeding article.

§ IX.—*Compound Fractures of the Femur.*

I shall not here recur again to the points which were sufficiently treated of in the general article on *Compound Fractures;* but a grave question has been started in regard to compound fractures of the femur, and a few words in reference to it will not be inappropriate.

In a very curious memoir, Ribes has represented amputation as unavoidable in gunshot fractures at the middle portion of the femur,

and such was likewise the opinion of Larrey. But Ribes went still further; he regarded fractures at either end of the femur as nearly equal in severity to those of its middle; he adds to these fractures of the leg also; and comes to this peremptory conclusion:

"That in almost all gunshot injuries of the bones of the lower limbs, the least delay in amputating may compromise the patient's life."*

I shared in this opinion, like most military surgeons, until I saw the mortality which followed amputations of the thigh done upon the field of battle, when I abandoned it; and for my own part, had I sustained a gunshot fracture of the femur, I would not submit to amputation unless under exceptional circumstances. I have had the satisfaction of finding my ideas in this respect confirmed by M. Marjolin; he had also tested by experience the value of amputation of the thigh for the lesion in question; in 1814, at la Salpêtrière, thirteen out of fourteen cases of this kind terminated fatally.

What particularly fortified Ribes in his conviction was, that he had not found at the Hôtel des Invalides a single soldier *who had had the femur fractured, with a wound of the adjoining soft parts.* But of the four thousand then in the hospital, there was not one *who had had the thigh amputated for fracture at the middle of the femur.* Whence we see that one class had no more escaped than the other.

Subsequently, between 1814 and 1822, Ribes received at the infirmary of the Invalides seven patients who had survived gunshot fractures at the middle of the femur. M. Sommé, arguing against that surgeon's opinion, has quoted three cases of cure after similar fractures.† I myself saw at Warsaw two persons whose thigh-bones had been broken in the middle, but were firmly united, although with deformity; and in the museum at Val-de-Grâce is a femur consolidated in admirable position, from a Swiss of the royal guard, who was wounded in 1830 by a ball striking this bone just at its centre. [A pamphlet published by Saurel of Montpellier, in 1856, entitled "*Mémoire sur les Fractures des Membres par armes à feu,*" contains notes of three cases of gunshot fractures near the middle of the femur, all terminating favorably, and two of them without any very notable deformity.] It must however be allowed, that such success is extremely rare; for instance, in his summary of the wounded of July, [1830,] M. Jobert gives three fractures at the upper, and three in the lower extremity of the femur, which were recovered from, but not one at its middle.‡ Perhaps it should be also stated, that he saw but one amputation for fracture of the femur; and there certainly must have been others.

* Ribes, *Mémoire sur la fract. du tiers moyen du fémur produite par armes à feu; Gazette Médicale*, 1831, p. 101.

† *Gazette Médicale*, 1831, p. 133.

‡ Jobert, *Plaies d'armes à feu*, p. 262.

In order further to clear up this difficult question, I shall present a sort of statement of the fractures of the femur treated at the Hôtel-Dieu in 1830.

There were admitted thirteen cases of gunshot fracture of the thigh. In eleven of these no amputation was performed, in some because the patients refused to submit to it, while in others it was not proposed to them; six died between the fourth day and the twenty-fifth; five recovered. Of these five cases, there was one at least, in a soldier, in which the fracture was at the middle of the bone; the precise seat of the others is not stated. In the remaining two cases amputation was performed, and both the patients died. One of them, indeed, should not be taken into account, since a second operation became necessary.*

We see then how grave these lesions always are, but also how decidedly the facts are opposed to the doctrine that we should always resort to amputation. The surgeon should duly take into consideration the conditions of the fracture, the state of the patient, and the surrounding circumstances, and base his judgment upon these data, without blindly obeying a general rule, which after all is perhaps only applicable in a minority of cases.

Compound fractures of the femur, produced by ordinary causes, although less serious than those from gunshot, may still sometimes call for amputation. While we are not to postpone this too long, we should avoid too hasty a resort to it; since even compound fractures of the condyles, with wounds laying the knee-joint open, have been conducted to a favorable issue by Desault, Sir A. Cooper, and others.

* Ménière, *l'Hôtel-Dieu en* 1830, p. 312 *et seq.*

CHAPTER XVII.

FRACTURES OF THE PATELLA.

Fractures of the patella are not very common; of the 2328 cases of fracture at the Hôtel-Dieu, they comprise only forty-five, at most one in fifty, or about four yearly. Hippocrates, Celsus, and Galen are absolutely silent on the subject; and Soranus is the first to give any description of them.

The cold season exerts a marked influence in producing them. Of the forty-five cases, twenty-seven occurred during the winter months.

But this influence is feeble compared with that of sex. There were thirty-seven men to eight women, or nearly five to one. Of twenty cases observed by myself, only four were in women.

The influence of age also merits attention. There was but one of these cases in which the patient was under seventeen years; I have myself seen only one case in a boy of eleven. From seventeen to thirty, there were ten cases; from thirty to fifty, twenty-one; from fifty to seventy, twelve; from seventy to eighty, only two. Thus the absolute number, for the same space of time, is nearly the same in youth as in adult age; it diminishes as life advances, and becomes very small beyond seventy years. But taking into the account the population, the predisposition evidently increases steadily from one to the other of these great periods of life, the two last-mentioned cases representing in septuagenarians as large a proportion as the twelve preceding them in persons between fifty and seventy.

The influence of old age seems especially marked in women; from seventeen years of age to fifty-five, they present but three fractures, but beyond this there are five.

Fractures of the patella may be transverse, vertical [longitudinal] or multiple, [comminuted;] we shall treat successively of each of these varieties.

§ I.—*Transverse Fractures of the Patella.*

I shall include under this head not only single transverse fractures, but also such as present splinters too small to be considered as distinct fragments.

The causes producing them are falls on the knee, direct blows, and muscular contraction.

Falls on the knee may be considered as the most frequent cause of fracture of the patella; of nine instances related by Boyer, five were ascribed to them, and I have myself observed, among nineteen cases, eleven thus produced. But it should be added that the resulting fracture is quite frequently multiple instead of transverse.

Much study has been devoted to the mechanism of this injury. Sue and Hevin thought that the patella bore by one end against the tibia, and by the other against the femur, and yielded in the middle; a strange anatomical error. Boyer is hardly less out of the way in asserting that the knee must be considerably flexed for the patella to receive the full force of the shock. I cannot agree with Camper, that when a man falls on the knees upon an even surface the patella is untouched; but any one may convince himself by kneeling down that when flexion is considerable, as in Boyer's view, it by no means rests upon the ground; that it touches the ground as the thigh is brought to a right angle with the leg, and that it strikes the ground by its anterior face just when the flexion is in the least possible degree. Sanson has advanced a more ingenious theory, viz., that in a fall on the knees upon an even surface, the direct shock is sustained by the spine of the tibia; and the patella bearing by its centre only against the femoral condyles, its two extremities are drawn backward above by the muscles and below by the tendon, or ligamentum patellæ; so that it yields at the middle, like a stick broken over the knee, in consequence of the muscular action.*

The defect in all these theories is that no account is taken of the conditions of the fall itself, the knee being supposed always to be strongly flexed, and the patient to come down, as it were, bent up. This does indeed take place, as was just now shown, in ruptures by muscular contraction; but when the fracture results from the fall itself, in the first place the knee very often strikes some solid object raised above the surface of the ground, as a stone, a beam, or a step; and again, in all cases the trunk is thrown forward; in one of my patients who fell in going up a staircase, this impetus was so great that his forehead struck one of the steps higher up, rendering him insensible. We may then regard it as settled, that the fall occurs with the least possible flexion, that the patella strikes upon its anterior face, at least in the majority of cases, and that the fracture is essentially direct.

Transverse fracture may also be caused by a direct blow, without any previous fall; but this is quite rare. Boyer has reported a case of transverse fracture resulting from the kick of a horse; I know of no other instance.

* *Gazette des Hôpitaux*, December 19, 1835.

It is generally under the influence of violent muscular action that the patella is broken transversely; but the conditions of this action may be quite various.

I have collected nine cases of fracture by muscular contraction; one of my patients had a double one. Four times it occurred in going down stairs, once in running down a slope, twice in walking along on level ground, once in the effort of giving a kick; once finally in a dancer, who heard a sudden crack while executing some movement, but made several steps, when his knee bent up and he fell backward. In the first seven cases, the fracture resulted from a false step, and by a powerful effort to bear back. Thus there ensued an opposition between the flexors, tending to incline forward at the same time the thigh and the body, and the extensors, tending to limit the flexion and preserve the equilibrium. The knee being slightly bent at the moment of the rupture, the patella may be considered then as balanced upon the condyles of the femur, and drawn upon at its extremities by two powerful opposing forces; Sanson's comparison would here be extremely appropriate, and the bone gives way at its middle like a stick broken over the knee.

My last two cases are not without analogues in science; Bichat speaks of a soldier who broke his patella in aiming a kick at his sergeant; and Hevin saw the same accident occur to a dancer who made a great effort in leaping. Here the extensor muscles, meeting with no resistance but the weight of the leg, first brought the limb into complete extension; and then only, contracting inordinately, they tended to carry this action still further, or, since the ligaments of the knee constituted an invincible obstacle to this, to break the patella. The fracture then occurs at the moment of complete extension; and this mechanism is still more evident in the case related by Bichat of a patient who was cut for stone, and who, in a consequent convulsion, broke both patellæ at once.*

Lastly, this fracture may occur when the knee is a good deal bent, perhaps even when it is extremely so. Thus Boyer speaks of a coachman who, being in danger of falling from his box, made an effort to hold himself on, and heard instantly the crack produced by the fracture. The muscles were here opposed only by the weight of the body. Fielding has published the case of a woman who sustained the same injury in trying to lift a heavy basket;† here again it was the weight of the body, but with the addition of that of the basket. Such cases must be quite rare, for I have found only these two.

* [The action of flexion being more powerful than that of extension, the flexor muscles would in convulsions fix the knee in a very much bent posture, and then the extensors would certainly act to great advantage on the patella. Is it not, therefore, probable that in the case last mentioned it was during a convulsive *flexion* that the rupture took place?]

† *London Medical Repository*, 1823, vol. xix, p. 174.

An important remark in connection with these ruptures by muscular contraction is that they are sometimes favored by an antecedent morbid condition of the patella. A patient admitted into Sanson's wards had suffered for six weeks from pains in the knee after a fall, when the fracture finally took place. I have reported, among other observations, the case of a member of our profession, who struck his knee severely against the wheel of a cabriolet, causing violent pain; next day he was going down a staircase, when he slipped; and although he held himself up by the baluster, he felt in the same knee a crack which too surely indicated a fracture of the patella. I have seen the same thing occur in a woman who a month before had sustained a bad contusion of the knee by a fall. It might indeed be alleged that the fracture had existed from the date of the first fall, and that the muscular contraction served only to break the fibrous bands still holding the fragments together. Perhaps it is so in some cases; but we have seen how in other bones pre-existing pain shows a disposition to fracture by muscular action, and the patella certainly forms no exception to this rule.

Transverse fractures present several varieties. In the first place, it must not be supposed that the bone is always broken directly across; very often the fracture is oblique to a marked degree, and always from above downward and from without inward; sometimes it has an angle or a curve in its course, and often there are one or two small splinters. Muscular action can only give rise to purely transverse or oblique fractures; all others are due to direct violence.

The seat of the fracture merits careful attention. It has seemed to me, in the first place, that purely transverse fractures are found in the middle or at the lower part of the bone, and that in the upper half the division presents commonly some degree of obliquity. I have seen a transverse fracture so low down that a superficial observer might have taken it for a mere separation of the ligamentum patellæ; and I have seen another in which the upper fragment was not more than one-third of an inch in length. According to several cases which I have carefully compared, a curious relation exists between the seat of the fracture and the determining cause; thus when the body is thrown backward to avoid a fall, and the extensors thrown into contraction to maintain the equilibrium, the rupture occurs rather in the lower portion of the bone; when the muscles act by endeavoring to increase the already complete extension of the limb, the bone yields at its upper part. But these conclusions need more ample proof.

There may be simultaneous fracture of both patellæ. Camper, Sue, Bichat, and Sir A. Cooper each saw an instance of this, and the two fractures represented in *Figs.* 79 and 80, and *Fig.* 84, belonged to the same individual.

But the most important point of difference is in regard to the de-

gree of separation of the fragments. *Figs.* 79 and 80 represent a fracture which was never suspected during life; the fragments had remained in contact by their posterior surface, and the separation seen in *Fig.* 70 involves solely the articular cartilage; there seems, however, to have been some slight separation at the outer surface. *Fig.* 81 is, on the contrary, an example of separation to an almost extreme degree. It may easily be seen how greatly the symptoms must vary in these two cases.

The primary phenomena also vary according to the cause. When the bone yields to muscular action, there is at the same time severe pain and a cracking noise at the seat of injury; the patient may still remain standing, or even advance some steps; but if he falls down, as commonly happens, he falls backward, with the leg flexed under the thigh. On the contrary, when the fracture results from a fall upon the knee, the patient always falls forward, or possibly somewhat sideways, the leg nearer to extension than to extreme flexion. Fractures by direct violence are also commonly attended by more or less extensive ecchymosis, which is wanting in most other cases.

After the fall, the pain is sometimes so great that the patient cannot rise, and has to be carried. Often, however, he can rise and walk with very little assistance; he then takes care to keep the leg stretched out as straight as possible, and by a sort of instinct he feels himself safer when walking backward and dragging the foot along the ground.

We must not be surprised at the various attitudes assumed by our patients when carried. Some keep the leg bent, and these are mainly such as have lost the use of the patella by muscular contraction, and have fallen backward; others keep it more or less extended, the least attempt at flexing it giving rise to excessive pain. The most usual position is however very slight flexion, or almost extension.

In this state, the knee appears swollen and deformed, the prominence of the patella flattened and elongated; and slight as may be the separation, a transverse hollow is perceptible between the fragments, or at least a flattened, quadrilateral space, increased by flexion, diminished by extension, and yielding under the finger so as to let it enter the hollow between the femoral condyles. When the effusion into the joint is considerable, this yielding is not so observable; but there is at least an evident degree of fluctuation. Above and below, the separated fragments may be recognised; and lastly, on bringing these together I have always been enabled to elicit crepitation.

When the contusion has been severe, the knee becomes the seat of actual inflammation, which may even induce a febrile movement. Generally, however, there is no fever; and sometimes the swelling itself is absent.

The inflammation, of whatever degree, ordinarily subsides from

the fifth to the tenth day, when the hollow between the fragments appears deeper, and the separation more marked. Fluctuation may still be perceived; but from the tenth to the fifteenth day it becomes more obscure, and by the fifteenth or twentieth it completely disappears. This is due to the absorption of the liquid part of the effusion, and the organisation of a uniting tissue between the fragments. The separation diminishes in nearly the same degree as the fluctuation; when this latter has disappeared, it seems to remain stationary; but I have sometimes seen it continue to grow less for a long time afterwards.

I traced very carefully the course of these two phenomena in two patients, a man and a woman. In the former the fracture was direct; the separation on the eighth day was fourteen millimètres; on the fifteenth it was reduced to ten millimètres, and fluctuation had entirely disappeared between the fragments, although still perceptible above and at each side of them. In the woman the bone had yielded to muscular contraction; on the ninth day the separation amounted to thirty-five millimètres; on the fifteenth it was diminished to twenty-five, and the fluctuation was almost gone; on the eighteenth there was only a separation of two centimètres, and no trace of fluctuation.

The consequences vary according to the conditions and degree of separation of the fracture, according to the nature of the callus formed, and especially according to the treatment employed.

In general thirty or forty days suffice for the formation of a firm fibrous or even bony callus; but the stiffening of the joint will already be very marked, and very difficult to overcome. This stiffening has seemed to me to vary, (1) according to the degree of the inflammation; (2) according to the period of confinement; (3) according to the pressure exercised by the apparatus; (4) and lastly, according to the time of application of the apparatus, whether before or after the occurrence of inflammation.*

Thus in the cases I have published, we find:

(1.) A simple roller, applied after the subsidence of the inflammation, and kept on for only thirty days; the stiffening was almost entirely dissipated by the end of three weeks.

(2.) The same, applied on the first day and removed on the fortieth; six years afterwards, the stiffening was still perceptible.

(3.) A uniting bandage, applied on the tenth and removed on the sixtieth day; for two years the patient could not walk unless with the aid of a stick; nearly three years afterwards, flexion could not be carried to a right angle.

(4.) The same, applied on the twelfth day, and kept on for nearly

* Malgaigne, *De quelques dangers du traitem. génér. adopté pour les fract. de la rotule; Journ. de Chirurgie*, 1843, pp. 201 and 236.

fifty days, in spite of pains in the joint; seventeen months afterwards, the knee could only be bent to 15° or 20°; the patient was obliged to use a crutch.

(5.) Simple position, maintained for twenty-four days; the patient had to use crutches for a year, and twenty-five years afterwards flexion was still incomplete.

(6.) An apparatus, kept on only for three weeks; but rest in bed for five months; two years afterwards, no flexion beyond 90°; perceptible limping.

(7.) Lastly, after the wearing of a starched apparatus for three months, union seemed to be bony; but at the end of the fourth month the leg could hardly be bent to 5° or 6°, and it was impossible to say what was the prospect of its becoming more movable.

Paulus Ægineta noted, as a consequence of fracture of the patella, the hindrance of movement, especially in making an ascent, due to the difficulty of bending the knee. Paré insisted on a grave prognosis, declaring that he never saw a single patient cured so as not to limp; Fabricius Hildanus was of the same opinion; and the stiffening was attributed to the formation of callus within the joint. We however see that this stiffening may in some cases disappear entirely, and that in general it diminishes in the course of time; I would add that while it exists to a certain degree, the patients appear to me to experience less difficulty in ascending a staircase than in descending. This is because the stiffening interferes mainly with flexion, and the knee must be bent to a much greater degree in order to go down easily than to go up. The difficulty in ascending arises from another cause, very often combined with the one just mentioned, but the effects of which should be kept distinct in the mind; this is the union of the fragments by fibrous tissue, never so firm as either the patella or its ligament, and weak in proportion to its length; so that the extensor muscles are doubly weakened, first by the want of solidity in their tendon, and second from their fleshy bellies being shortened and farther removed from their common insertion. The stiffening therefore interferes more essentially with flexion, and the fibrous structure of the callus with extension.

The greatest separation within my knowledge was seen by Sir A. Cooper, and measured over four inches; then comes that figured by Camper after a specimen in the museum of La Haye, which exceeds three and one-third inches. Perhaps, however, we should not rely implicitly upon anatomical preparations; the fibrous tissue may be much stretched in dissection; thus *Fig.* 81, correctly copied from a sketch, presents a separation of about two inches and a half, while before dissection it was only about two inches. It may be seen besides, that this elongation after death is the more considerable in proportion as the fibrous band is longer and thinner.

Even during life the band may likewise be stretched by bending

the knee; but the shorter and thicker it is, the less marked is its yielding. In a patient in whom the fragments were but eighteen millimètres [three-fifths of an inch] apart during extension of the limb, flexion increased the separation to twenty-two millimètres; the fibrous band was very dense at its middle portion. I have seen, on the contrary, a man in whom the separation, amounting to an inch with the limb extended, was nearly doubled by flexion of the knee. The fibrous band was very thin; the extension also was incomplete, and what is very remarkable, the upper fragment, perfectly movable under the fingers, was unaffected by all these motions, as if deprived of all connection with the other.

The consequence of this separation is therefore a notable loss of power in the extension of the limb. Camper has stated, indeed, that in one or two years the power is recovered, whatever may have been the interval between the fragments; an evident exaggeration, since he himself speaks of a lady with a separation amounting to three fingers'-breadths, who still limped four years after the receipt of the injury. Mr. Benjamin Bell makes one inch the limit of separation allowing of the restoration of the firmness of the knee; Boyer follows him; M. Velpeau, on the contrary, asserts that he has seen the functions of that joint completely re-established, with an interval of two or three inches between the fragments.

Such assertions are in my opinion only accounted for by some inaccuracy in examination; and for my own part, I have never seen the functions of the limb completely restored, even when the separation was limited to one-third of an inch. I have carefully examined a member of our profession, whose case is cited as one of complete recovery; the space between the fragments is about two-thirds of an inch, and the patient, tormented by a constant mistrust of the strength of his limb, would not dare to ride a horse on a trot, to go up two stairs at a time, or to run with any speed upon a level surface; and especially is he unable to carry a load of any weight, his knee giving way if he attempts it. This inconvenience is much more serious to a working man; I have seen a turner obliged to abandon his occupation because he could not stand long; the porters at the market-house lose more than half their capability of carrying burdens; I have seen one man come down from 400 pounds to 250, and another from 1200 to 400. Walking long distances becomes also more fatiguing; thus the man last mentioned, who could before his accident walk fifteen or twenty leagues in a day, was unable afterwards to exceed ten or twelve. Lastly, patients become fatigued particularly in making ascents; which is explained by the effort necessary for the extensor muscles to straighten the thigh and trunk on the leg as the foot is placed on each step. They however for the most part learn to go up without apparent difficulty, when once they overcome their instinctive want of confidence; but the inconvenience

recurs when the step happens to be a high one, or if they try to mount two stairs at a time.

Some are not so fortunate; sometimes the extension is so unsteady that I have seen a patient who could not draw on his stocking without turning his leg to one side; sometimes the muscles have not even the power of producing complete extension. It is readily seen how vascillating this must render the gait. "We know," says Boyer, "several persons in Paris who are in this condition, and who are obliged to wear a sort of contrivance to hinder the bending up of the knee;" and then it is still necessary to steady the walk by a cane or a crutch.

Lastly, this weakness may go still further, and the power of extending the leg be almost entirely lost; J. Hunter and Sir Astley Cooper have quoted very remarkable cases of this kind.

These are undoubtedly very troublesome consequences, but they sometimes involve others of still greater severity. The weakness of the injured limb induces the patient to instinctively throw all the weight of the body on the other, especially in making any great effort; the sound patella at length gives way, and is fractured in its turn. Meuschner reported the first example of this; Bromfeild again called attention to it; Camper says that he saw a good many such cases of secondary fracture; Sir A. Cooper also frequently observed its occurrence.

This would however seem to me to be less common, and far less serious, than the rupture of the fibrous tissue connecting the primitive fragments. Heister was the first to mention the latter; he knew of several instances. Morgagni reports two cases; others have been seen by Richter, Ortalli, Dupuytren, MM. Roux and Velpeau; I have myself seen a woman in whom the rupture occurred for the fourth time. It is asserted that union takes place as firmly as before; which however I am disposed to doubt. But it is only too certain that these ruptures of the callus may involve that of the skin, thus laying open the articulation. Sir Charles Bell reports such a case, the immediate cause being a fall backward; it became necessary to amputate the limb. I have seen a nearly similar instance; the rupture of the fibrous band was attended with enormous ecchymosis, gangrene ensued at about the fifth day, and death closed the scene. Lastly, M. Seutin quite recently sought in vain to save a limb thus affected; after four months' suffering amputation of the thigh became the only resource.*

Such are the unfortunate consequences which threaten patients with badly united fractures of the patella, as far as clinical observation enables us to trace them. But pathological anatomy has given us some light, revealing especially a singular form of secondary displacement of the lower fragment.

* *Journal de Chirurgie*, 1846, p. 120.

And in the first place, whence arise the variations in the degree of separation of the fragments? Gulliver, having fractured the patella transversely in some of the lower animals, found that when the fibrous tissue covering the anterior face of the bone was unbroken, the fragments remained in contact; while if this layer was divided they at once parted from one another by from four to twelve millimètres.* This fibrous layer is therefore of importance in connection with this fracture; and yet the complete destruction of it cannot in my opinion suffice to induce a separation even to a slight degree. Often, in the dead subject, I have divided it transversely along with the patella, with a knife; as long as the section went no farther than the edges of the bone, the fragments could hardly be separated by the most powerful traction. To pull them apart by only half an inch or an inch, both sides of the fibrous capsule had to be divided; and to obtain an interspace of three to four inches, I was obliged to isolate the upper fragment by extensive longitudinal incisions through the aponeurotic sheath and muscular fibres of the quadriceps.

Secondly, in what does the effusion consist which comes on so rapidly in the cavity of the joint? Sir A. Cooper, having divided the patella transversely in rabbits, found at the end of forty-eight hours that the space between the fragments was filled with coagulated blood. M. J. Cloquet verified the same phenomenon in man. An old man of sixty-six had his patella broken by a carriage-wheel passing over it, and died on the eighth day. The joint was enormously distended with blood and synovia, and it was from the fractured surfaces alone that the hemorrhage had proceeded.†

Sir A. Cooper traced the progress of organisation in rabbits. By the eighth day the greater part of the blood was reabsorbed; a plastic material occupied the space between the fragments. On the fifteenth day this material had assumed a smooth ligamentous aspect, and on the twentieth it was completely fibrous; finally, after five weeks, a fine injection showed the vessels running from the edges of the capsule into the interior of the new tissue; some, but only a small number, came from the bone itself.

In the dog this process is not quite so quickly accomplished as in the rabbit; in man it is still more tardy. We have seen the stage which M. J. Cloquet's case reached by the eighth day. I have witnessed a dissection on the sixteenth day in a man of forty-three, whose thigh it had been necessary to amputate. Between the two fragments there was a clot of blood whose greatest consistency was in the vicinity of the fractured surfaces; here it was of almost cartilaginous firmness, and seemed already to form one mass with the bone.‡ It is therefore the commencing organisation which causes

* *Gazette Médicale de Paris*, 1841, p. 412.
† *Bulletins de la Faculté de Médecine*, 1820, No. 6.
‡ *La Clinique des Hôpitaux*, June 14, 1828.

the subsidence of fluctuation by the fifteenth or twentieth day, as I have observed in the living subject; and it may be presumed that twice as much time is required to complete this in man as in the rabbit.

I have studied the arrangement of the fibrous callus in a fracture of the patella of two years' standing. (See *Fig.* 81.) The skin was perfectly normal in aspect; but at the level of the callus the superficial fascia was greatly thickened, and strongly adherent to the subjacent tissue. The bursa over the patella was lost in these adhesions, not the slightest trace of it being perceptible. Without counting this reinforcement of the superficial fascia, the fibrous band was seen, when examined near the upper fragment, to be divisible into three layers, to wit: (1) the tendinous fibres covering the patella in the normal state; some of these were directly continuous with those of the callus, while the deeper ones, passing off from the upper fragment, lost themselves in a very marked prominence of the fibrous tissue, seen posteriorly about one-third of an inch below it; (2) fibres belonging to the periosteum, which lost themselves in the same fibrous mass; (3) short, thick fibres, interspersed with fat, arising from the whole fractured surface, forming the fibrous mass alluded to, and giving it a very considerable degree of consistency. Below this the callus was composed only of the superficial fascia and of prolongations of the outermost fibres of the tendon. It was therefore very thin in the middle, and only regained a notable thickness close to the lower fragment. At the sides, however, the fibres extended from one fragment to the other, giving these portions of the callus greater thickness and solidity.

In another case, the fibrous tissue was thicker at the centre than laterally, but still showed the same increase in its mass toward either end. Nothing can be more irregular than these variations of form; only if we compare, for instance, the thickness of the callus with that of the ligamentum patellæ, we can easily see that the former could not withstand any severe strain.

It has also been mentioned that the shortened muscles lose much of their power. This feebleness at length displays itself in a sort of atrophy; thus in the subject of *Fig.* 81 they were both thinner and paler than those of the sound side; the vastus internus had lost one-third of its normal thickness, and fat was already deposited among the fibres.

The upper fragment, drawn up higher than in the normal state, makes for itself a sort of new articulation. In two patients in whom I have had the opportunity of dissection, the synovial membrane presented opposite this fragment a narrowed opening, leading to a supplementary serous cavity; this cavity was just over the thickened and almost cartilaginous periosteum, and the bone beneath was slightly hollowed transversely. The fragment only preserves its

articular cartilage at the points of contact of the new joint. We see for instance in *Fig.* 81 that the cartilage does not cover more than half of the upper fragment; the rest is overspread with fibrous tissue and synovial membrane. In *Fig.* 84 we observe a small elliptical surface still retaining its cartilage; all around it are irregular eburnated prominences of the bone.

Lastly, careful examination generally shows that this fragment is somewhat inclined upward and backward; but this inclination is nothing to compare to that of the lower fragment downward and backward.

If we look attentively at *Fig.* 81, we see that the cartilaginous face of this latter fragment, in place of looking backward, is turned almost directly upward, and coated with the fibrous tissue of the callus. The fractured surface therefore looks forward; the anterior face downward, and the point, turned backward, is rounded off by pressure; so that in order to comprehend this curious malposition, the bone had to be divided vertically, keeping the articular cartilage intact. I have traced this version of the inferior fragment in the living subject; I have three times had the opportunity of verifying it by dissection, and it may be recognised in the dried specimens in our museums. *Fig.* 82, for instance, was drawn from a preparation in the Musée Dupuytren; the fracture would seem horizontal in the upper fragment, while in the lower it presents a very marked obliquity downward and forward. This oblique surface is really that of the fracture, but changed in direction by the sort of version above described.

Some forms of apparatus favor this movement; but apart from this quite secondary cause, it is the gradual and spontaneous result of the retraction of the ligamentum patellæ; the anterior fibres of which, longer than the others, also retract more, and draw down the anterior face of the lower fragment, into which they are inserted. I detached the ligamentum patellæ as close as possible to the tibia, in the subject of *Fig.* 81; its average length was one inch, while that of the sound side was nearly twice as long. The ligament in this state of retraction was also very thick, as may be judged from the figure. Thus, the ligament in retracting had not only caused the lower fragment to describe nearly a quarter of a circle, but had drawn it down an inch below its normal position; producing in this case a more marked effect than the muscles themselves had.

These altered relations of the fragments undoubtedly interfere somewhat with free flexion of the knee; I have several times, for example, seen the upper fragment caught by the upper edge of the articular face of the femur. But this is not the only obstacle; for even the ablation of the patella does not render flexion perfect. In a case of this kind I have seen the crucial ligaments put strongly on the stretch; and they were torn by bringing the heel up to the buttock. There were in the joint neither false membranes nor adhe-

sions; the stiffening, except the slight amount caused by the patella, was therefore due entirely to the contraction of the crucial ligaments.

There remains lastly the great question as to bony union in transverse fractures of the patella. Pibrac even denied its possibility, and offered a prize of one hundred louis to any one who would show him a patella *entirely united* by ossific deposit.* Since that time its occurrence has been demonstrated by Camper, Sheldon, Boyer, and others; I have sometimes seen it myself, but, what is very essential, never in simple transverse fractures; there was always at least one small splinter broken off from one of the fragments. The specimen represented in *Figs.* 79 and 80 affords a very fine example of union of a simple transverse fracture, but the separation was so slight that the nature of the injury remained undetected during life.

In fact, if I mistake not, the whole difficulty arises from the amount of separation of the fragments. In simple transverse fractures, due almost always to muscular action, the patient falling backward with his knee strongly flexed, the rupture of the fibrous tissues is as extensive as possible; the separation is generally greater than in fractures from direct violence, in which the knee is hardly bent at all. In this latter case the periosteum and the fibrous tissue behind the bone are in great part preserved, and this periosteum naturally plays an important part in the reparative deposit of bone. Indeed, in Gulliver's experiments, whenever the patella was fractured without injury to its periosteal covering, bony union took place; when, on the contrary, this covering was divided, union was always fibrous.

The cause of this rarity of ossific union is therefore that the plastic material thrown out partly by the fractured surfaces, but mainly by the periosteum, cannot fill up the interval between the fragments. In some cases we cannot but wonder at nature's efforts; thus in *Fig.* 84, the lower fragment is surmounted by a bony stalactite nearly one-third of an inch in height, passing in front of the upper fragment, which it could not reach. In one of Camper's figures,† a similar prolongation is seen joining together, with the aid of a small intermediate splinter, the two principal fragments, while at each side the union is purely fibrous; showing the value of splinters. Sometimes, lastly, analogous stalactites spring from the edges of the bone, nature's efforts at repair being misdirected. The cartilage takes no share in the process of reunion, as may be well seen in *Fig.* 79.

On the whole, ossific union taking place in the majority of cases with some separation of the fragments, the bone remains elongated and deformed; and I am not sure that this deformity does not interfere as much with the functions of the knee as union by fibrous tissue would. Boyer relates a case of this kind; the patella was elongated

* *Pratique Moderne de la Chirurgie*, by Ravaton, tome iv, p. 336, note.
† *Dissert. de fract. patellæ et olecrani*, Hagæ-Com., 1789.

by about six lines; the patient was obliged to use a cane for a year, and thirteen years afterwards the flexion of his knee was still limited. I have myself published a case of bony consolidation obtained by M. Blandin; the increase in length of the patella was estimated, during life, at eight lines; at the end of the fourth month the leg could hardly be flexed five or six degrees. I sought in vain to find this man subsequently.

The diagnosis is generally very simple; a considerable separation strikes the eye at once; if the separation is but slight we should seek to move the fragments in different directions, to elicit crepitation. Only excessive swelling may constitute an obstacle to this investigation; and this must be carefully treated.

Nevertheless, when the separation amounts to only a few millimètres, permitting neither movement of the fragments upon one another, nor the resulting crepitation, there is a cause of error which was pointed out by Sanson, and which I have several times observed. A fall on the knee upon some projecting body may break across the fibrous capsule investing the patella, without involving the bone itself; then with the finger or with the nail we recognise a transverse fissure, which simulates exactly that of a fracture without displacement. Sanson adds that sometimes the commencing inflammation of the knee gives rise to a rubbing sound when the knee is moved, resembling crepitus, and cites a case in point. A little attention will always suffice to recognise true crepitation; but the existence of the transverse fissure is more likely to lead the surgeon into error. When we have not for our information any mobility of the fragments, or any crepitation, there still remains one resource; this is to try whether by slightly flexing the joint, the fissure can be widened, and whether a fine needle can be introduced between the fragments. We see, however, that there is some risk attending these measures, and often it is better to await the further progress of the case. Some days' rest will allay the pain due to mere rupture of the fibrous tissue behind the patella, but that of a fracture will still persist.

In regard more especially to flexion of the leg we should observe extreme caution, to avoid the laceration to which it may give rise. J. L. Petit mentions a bone-setter who, for a traumatic lesion of the knee, undertook to make alternate flexion and extension of the leg, carrying each as far as possible; the first attempt threw the patient into a syncope; at the second, he died.

The prognosis may be derived in great measure from the preceding considerations, but it varies somewhat, mainly according to the treatment employed.

A great many plans and forms of apparatus for treating fracture of the patella have been devised, which may however be classed under three principal heads. The first aims at securing the firmest union, and consists essentially in keeping the limb immovable; the

second has for its main object the prevention of stiffening, and is distinguished by making extensive motion of the joint long before the process of union is completed; the third, being a combination of the two former, may be called the *mixed plan.*

First Method.—This seems the most natural, and was the one earliest employed. It is itself divided into two secondary methods, according as mere position is relied on, or as contrivances are used for approximating the fragments.

Paulus Ægineta and Paré merely kept the leg extended, by means of splints, long compresses of straw, or troughs. J. L. Petit did indeed advise also the putting of the leg upon *a pillow raised toward the foot;* but with no other idea than that of more certainly securing extension, and favoring the return of the blood. In 1772, Valentin showed that merely extending the leg did not sufficiently relax the rectus femoris muscle, and recommended raising the heel as much as possible. Accordingly he arranged pillows in an ascent beneath the thigh and leg, at the same time putting the foot into a slipper, attached by three bands to a body-piece surrounding the chest of the patient. Richerand retained the cushions, but abandoned the slipper. Sabatier, remarking that the absolutely straight position induced insupportable pains in the ham, thought that the knee ought to be bent to a slight degree; but in order not to lessen the relaxation of the rectus femoris, he advised that the flexion of the thigh on the pelvis should be increased. With a view also of preventing the pillows from sinking in, he had sewed to each corner of the one supporting the leg a riband, by which it was suspended from the curtain-frame; and this was the first attempt at suspension without a machine.*

Lastly, in 1789, Sheldon showed the impropriety of the extended position still more plainly than Valentin had. In a subject six feet and one inch in height, he found the distance between the two points of attachment of the rectus femoris, the hip and knee being straightened out, to be twenty and a half inches, and with the hip bent at a right angle, only eighteen inches. Hence he advised, and most English surgeons follow out the idea, that the patient should be seated in bed, his body vertical or even inclined slightly forward; and that when this posture becomes fatiguing, the body should be allowed to lean backward, the limb being proportionately raised.†

* Valentin, *Recherches crit. sur la chir. moderne*, Amsterdam, 1772; Richerand, *Mém. sur les fract. de la rotule*, in the *Mém. de la Société Médicale d'Emulation*, tome iii; Sabatier, *Mém. sur la fract. en travers de la rotule; Mém. de l'Acad. des Sciences*, 1786. I do not know where Boyer found the statement that Sabatier made his patients lie on the side.

† Sheldon, *An Essay on the Fracture of the Patella*, etc., London, 1789. I have not been able to procure this work, and quote from Camper and Monteggia. [I have consulted the book in question, but find nothing said of seating the patient in the manner mentioned; the only plan spoken of is, *to lay the patient on either side, with the injured limb flexed; the amount of flexion being regulated by the evident relaxation of the extensor muscles.*]

Whatever position may be preferred, it is too evident that although the space between the fragments may be diminished, it cannot be obliterated. There are two muscles to be relaxed, the triceps [comprising the crureus and the two vasti] and the rectus femoris. The former, which has received scarcely any attention, is much the more powerful of the two; the only means of relaxing it is to keep the leg in a straight line with the thigh; but both clinical observation, and experiments on the lower animals, show that mere extension is insufficient to enable us to bring together the two portions, if this muscle be divided transversely.* Hence it is very nearly useless to keep the patient in the fatiguing posture prescribed by Sheldon, which does not affect the triceps at all; that advised by Valentin is to be preferred, not because it is more efficient, but because it is more supportable. But it requires for its maintenance some surer means than cushions or even lateral splints. Desault was the first who conceived of putting a strong splint beneath the joint itself, and it is better to have a board of a proper width reaching from the buttock to the heel.

But since the desired end is not attained by extending the leg, ought we not to make use of slight flexion, in order to obviate the severe pains sometimes observed by Sabatier, as well as by Boyer after him? I should say in reference to this that the pains are generally of short duration, that they may in most cases be prevented by applying compresses under the ham, so as to hinder any distortion of the joint, and that we might as well at least wait till the position is complained of before changing it. In fact, the slightest bending of the knee, increasing the separation, increases the tension of the triceps, which is by far the greatest difficulty with which we have to contend.

Our apparatuses require therefore to be seconded by position; but position cannot be sufficient without some apparatus.

These contrivances have been so multiplied, that in order not to be lost in a barren enumeration, we must class them according to their principal types; these are founded on their mode of action. I make thus four groups, viz.:

(1.) *Apparatuses for circular pressure*, having for their object to embrace more or less exactly the contour of the bone.

(2.) *Appdratuses for parallel pressure*, acting on each fragment, across the axis of the limb.

(3.) *Apparatuses for concentric pressure*, acting from above downward and from below upward upon the edges of the respective fragments.

(4.) Lastly, such as act only on the upper fragment.

The first suggestion of circular pressure is to be found in Albu-

* See my *Anat. Chirurgicale*, tome i, p. 107.

casis, who covered the patella with a round splint, that is, a splint perforated in the centre, and kept in place by a bandage; this apparatus was approved of or modified by Guy de Chauliac, J. de Vigo, and Bassuel, and was still employed at the Hôtel-Dieu in Paris, in the latter half of the eighteenth century. We should also mention (1) Purmann's ring, made of twisted iron wire, and wrapped in a double covering of leather; (2) the *petit chapeau*, *pileolus*, or little hat of Meibomius, modeled upon the sound patella, sufficiently concave to be stuffed with cotton, and bearing by a wide brim upon the neighboring parts. Sometimes the author cut this instrument (which was probably made of wood or cork) in half, in order to apply it more readily, fastening the two portions subsequently with an iron ring; and lastly, in case of a wound, he left a fenestra in the centre; (3) the wooden cap of Kaltschmidt, which would seem to be an imitation of the *petit chapeau* of Meibomius, etc.* Nothing like these is in use at the present day; they cannot indeed afford either the accuracy of application or the power of those which succeeded them.

The apparatuses acting by parallel pressure have been more successfully used. The first of these was devised by a mechanic of Leyden, named Muschenbroëk; it was described by Solingen, published in France by Blein, and almost at once copied by Arnaud, who gave it his own name. As modified by Arnaud, it consisted of a trough of sheet-iron or tin placed beneath the ham, provided with a fenestra so that this part might be moistened if necessary, and having holes cut for screws close together along each lateral margin. Two wide concave plates with holes corresponding to these, were applied one above and the other below the patella, and fastened by means of screws passed through the holes above mentioned. It is probable, though not stated, that the limb was first protected by compresses from undue pressure.†

I have dwelt upon this contrivance, both because it was the earliest, and because it became the type on which all the rest were modeled. In fact, if we substitute for the trough of metal one of wood or leather, or even a simple splint to support the leg and ham; if we replace the two wide plates intended to approximate the fragments by narrower ones, semicircular or horseshoe-shaped, making them, provided they are duly padded, of iron, cork, or leather; if we confine these to the trough by straps passing around transversely; then if we bring them toward one another by means of screws ar-

* See the *Mémoire* of Bassuel, analysed in the *Bibliothèque* of Planque; the thesis of Allouel, Paris, 1775; and the thesis of Meibomius, 1697, reproduced in the *Diss. Anatom.* of Haller, tome vi. Kaltschmidt's apparatus is represented in Richter's Atlas.

† See for the account of this machine Solingen, quoted by Richter; Garengeot, *Traité des Instruments de Chirurgie; La Chirurgie Complète*, by Leclerc; and Duverney's treatise.

ranged in any way, at the sides or in the middle, or even by means of straps running alongside of the patella; or if we use, instead of all this, two thick compresses, one above and the other below the bone, pressing them together by bandages or handkerchiefs,—we have the forms of apparatus proposed by Bücking, Evers, Böttcher, Aitken, Lampe, Graefe, Morgridge, Mayor, etc.* The uniting bandage, first recommended by Heister, and adopted by Larrey and Dupuytren, is still sometimes employed in our hospitals; but the relaxation of the material composing it renders it the least reliable of all our appliances.

The origin of the plan of concentric pressure is to be found in the figure-of-8 made with a double-headed roller, as described by Lavauguyon. To this were soon added graduated compresses of linen, or plasters, so as to act more forcibly upon the fragments; such is the apparatus described by J. L. Petit; and this simple plan has gained numerous partisans. But the unavoidable occurrence of relaxation of the bandages soon led to the employment of firmer materials; hence the contrivances of Ravaton, Allouel, Boyer, Buirez, Assalini, etc., which are all composed of a straight trough, with a strap embracing each fragment, and fastened at the same level on each side; except that of Ravaton, in which the trough is curved so as slightly to flex the leg. I shall describe only Boyer's apparatus, as combining great efficiency and great simplicity.

This consists of (1) a hollow wooden splint long enough to reach from the middle of the thigh to below the calf, deep enough to take in two-thirds of the thickness of the limb, and well padded inside, having at about the middle of each edge nails, with rounded heads, ten or twelve millimètres apart; (2) of two straps about an inch in width, whose middle third is formed of buffalo-hide, padded with wool and lined with chamois-leather, and the outer third on each side of calf-skin, with holes four or five millimètres apart; (3) of five or six loops of ribbon or bandage. The limb is placed in the trough, all the interspaces being filled with cotton; then while an assistant approximates the fragments, the straps are arranged one above and the other below the patella, their extremities being fastened at either side, it may be on the same nail; or sometimes the upper strap catches on the lower nail, and the lower strap on the upper nail. Compresses dipped in some antiphlogistic solution are now laid over the patella, and the whole is confined by means of the loops knotted upon one side of the trough, or perhaps with a roller.

Quite recently, M. Velpeau has again adopted the figure-of-8, giving it however by the addition of dextrine a firmness, of which simple bandages are destitute. The limb being moderately extended,

* Most of these are given in Richter's Atlas; that of Morgridge may be found in Amesbury's work.

and the two fragments brought as nearly together as possible, the knee is first covered with fine dry linen; after which graduated compresses are placed transversely above and below the patella, and confined by oblique turns of a roller passing beneath the ham. This done, the first layer of the dextrinated bandage is applied, reaching from the foot to the fold of the groin. A moistened sheet of pasteboard is now disposed beneath the limb, from buttock to heel, and the second and third layers of the dextrinated bandage complete the apparatus. A wooden splint is temporarily applied until the whole is dry.

I have also seen the figure-of-8 applied by M. Gama, by simpler and much more powerful means. Instead of ordinary bandage, M. Gama uses very long strips of adhesive plaster, which when once put on over the graduated compresses, are not so likely to relax as the dextrinated apparatus is, at least before its entire consolidation; they moreover leave the patella exposed, and enable us to increase or diminish the pressure as the case may require.*

There remain to be considered apparatuses acting solely upon the upper fragment. The principle was suggested by Pott, who, regarding the lower fragment as essentially immovable, applied merely a small compress above the upper fragment, retaining it in place by a moderately tight bandage. The idea obtained favor both in England and Germany; and hence the more complicated contrivances of Benjamin Bell, Böttcher, Sir A. Cooper, Amesbury, etc. Bell and Amesbury, however, both kept up a certain action upon the lower fragment, by means of a transverse strap or plate drawn toward the upper one as in the apparatus for parallel pressure; but their essential aim still was to draw the upper fragment downward by means of loops attached to a shoe worn by the patient. Bell used a single strap fastened at the point of the shoe; Böttcher dispensed with the shoe by employing two straps meeting beneath the sole of the foot, like a stirrup. Sir Astley Cooper encircled the limb above the upper fragment with a leather band, fastening it with buckles; from one side of this there descended a single long strap, which passed under the sole, came up along the other side of the leg, and was again attached to the circular band.

All apparatuses of this sort have two grand defects; in the first place, by drawing down the upper fragment without fixing the lower, we merely push the latter downward, thus voluntarily losing the advantage of reciprocal pressure of the two fragments, so important in

* Adhesive plaster has also been employed by Alcock, in England; see his "Practical Observ. on Fract. of the Patella," etc., analysed in the *London Med. Repository*, 1824, vol. i, p. 496.

[Alcock's plan was to carry strips obliquely across, each way, above the patella and down to the ham; the upper fragment being thus in the angle between the two sets of strips. He used also a compress, and a loosely applied bandage; and speaks of the strips as not essential.]

insuring their contact and hastening consolidation; secondly, we have seen that the lower fragment is apt to be drawn down and tilted over by the retraction of the ligamentum patellæ, and hence that we must act upon this fragment as well as upon the other.

On the whole then, mere position being almost always insufficient, and apparatuses acting by circular pressure or by pressure on but one of the fragments being excluded, there remain only those which act by parallel and by concentric pressure. Now if there is any fact in surgery which is incontestable, it is that of their inefficiency in procuring regular and firm union. This inefficiency is due to various circumstances.

In the first place, the patella does not present such external prominences as to allow these apparatuses sufficient purchase. The extensor tendon is not inserted behind the edge of the bone, but rather in front of it, since some of its fibres pass over its anterior face; and the same is true also of the ligament which completes it. We must therefore depress both these strongly, in order to make hollows above and below the bone into which the straps may sink. Now the contractions of the muscles tend constantly to efface these hollows, raising the straps to a level with the anterior face of the bone, and making them slip for want of purchase. When by strong pressure we obviate this danger, another instantly arises, which I believe I was the first to point out.

This is, that in forcing the tendon into the hollow above the condyles, and the ligament into the depression between the femur and tibia, we make the fragments tilt strongly backward, so as to widely separate the fractured surfaces in front. They may indeed be thus brought into contact, but the contact is partial and limited to the posterior edge of the fracture; in front there remains an interspace so marked that the skin may sometimes be pushed into it. I was first struck with this in a man who came to the *Maison Royale de Santé* to be treated for a fractured patella, which had united by fibrous tissue. There was no swelling of any kind; the muscles were supple and easily stretched, so that I could readily bring the fragments in contact by their posterior edges, but the hiatus in front still remained, and could not be obliterated. Since then, out of a good many recent fractures, in which the swelling always obscures the part somewhat, I have occasionally thought that with the fingers I made perfect coaptation, but this was always lost on substituting any apparatus for the fingers. In experiments on the dead body, pulling upon the muscles to represent their natural contraction, I have shown M. Mayor of Lausanne that his apparatus is as liable as any other to this serious inconvenience.

When we examine fractures of long standing, united only by fibrous tissue, it is perhaps difficult to distinguish in regard to this phenomenon how much is due to retraction of the ligamentum patellæ,

and how much to the apparatus used. But when there has been bony union, the former cause is excluded. Now in the case reported by Boyer, the injured patella was longer by six lines than the sound one, and in the figure the transverse fossa separating the two fragments anteriorly was recognisable, explaining the increase of length. In M. Blandin's patient I found the injured patella longer than the other by eighteen millimètres; through the integuments there could be perfectly perceived a transverse fossa, limited by the anterior edges of the fractured surfaces, and having a width exactly equal to the increase in the length of the bone.

This tilting of both fragments is never so marked as when the fracture occupies the middle portion of the bone. When the fracture is near either extremity, it is only the larger fragment which is thus inclined, the smaller being simply depressed along with the tendon or ligament inserted into it. Monteggia was struck with this fact; in a fracture seated in the upper fourth of the bone the upper fragment was deeply sunken, while the other was rendered prominent; to efface this prominence, it was necessary to make pressure directly upon it. M. Ph. Boyer saw likewise, in a case in which the point of the bone was torn off, the upper fragment so tilted that the least pressure on the ligamentum patellæ turned it back, so to speak, and that he had to use means bearing directly on the projecting fragment in order to retain it in place.* I have myself observed analogous cases.

Lastly, there is one more disadvantage which has also escaped observation. The lower strap bears quite accurately upon the point of the patella, which is nearly in the median line; but the upper one presses upon the base of the bone, which is directed obliquely, its outer extremity being nearly one-third of an inch above the level of the inner. The pressure is therefore greater at the outer than at the inner side, the approximation more close, and the union more solid. Thus in Boyer's specimen, before alluded to, the callus is complete externally, but leaves a notable gap internally. Boyer has himself remarked that the upper fragment was tilted away from the other so much as to form with it an angle of 130°, opening outward. I have met with the same appearance in fractures united by very short fibrous bands, of which the outer portion is always the shorter.

With apparatuses for parallel or concentric pressure, therefore, we generally obtain only fibrous union, for want of coaptation; and when we do obtain coaptation, it is usually still deficient at the anterior and inner part. The only advantage of the former method, as hitherto applied, is to diminish the separation of the fragments,

* See the additions in the new edition of Boyer. M. Ph. Boyer alleges in this same passage, that the tilting of the fragments is owing solely to improper application of the bandage, adducing as proof the success of his own cases. I regret that I cannot agree with him.

and thus to procure a shorter and firmer uniting band. But this advantage is quite dearly bought at the expense of the stiffening which almost inevitably attends such treatment; and hence surgeons have sought some other means of attaining it.

Second method.—This plan was devised in England at about the middle of the last century. Warner, in 1754, speaks of it as adopted by a majority of the London surgeons; Camper introduced it into Holland, and Flajani into Italy.* These authors differ somewhat as to the manner of its application.

Thus Warner, having to treat a young woman for a broken patella, approximated the fragments within an inch, and kept them in place at first with a bandage. But some days afterwards he began carefully to make alternate flexion and extension of the knee, and repeated the operation daily for about six weeks, when he considered the cure to be complete.

Camper likewise applied a bandage during six, eight, or ten days, and then made his patients get up and walk about.

Lastly, Flajani dispensed with all bandages, treating the swelling at first by position and fomentations. The swelling having subsided, he directed the patient to bend the knee in bed several times a day, and after a day or two to get up and walk, first with crutches and then with merely a stick. Of three patients whose cases are given, one got up on the thirteenth day, and the other two on the ninth; one could walk freely without a stick by the eighteenth day, the second by the twenty-sixth, and the third not until the sixty-fourth.

It is evident that the stiffness so frequently resulting from treatment by the first method is obviated by this one; and Pott asserts that the patients who walk best after fracture of the patella are those who have been made to move the knee from the time of subsidence of the inflammation, and in whom a certain interval exists between the fragments. We have, however, seen the true value of this union with an interval; and several surgeons have sought to combine the two plans, so as to secure the suppleness and at the same time the firmness of the knee.

Third or mixed method.—Solingen, according to Camper's account, while endeavoring to keep the fragments in apposition, advised occasional bending of the knee to obviate anchylosis. Bromfeild, with still greater prudence, waited for the inflammation to subside before he put on any apparatus, and only attempted daily and gradual flexion of the joint at the end of the third week. Mr. Benjamin Bell, on the contrary, applied the apparatus from the commencement, took it off for the purpose of making gentle flexion on the twelfth or fourteenth day, replaced it, and renewed the process of bending

* Warner, *Observ. de Chirurgie,* [*Cases in Surgery,* Lond., 1760,] French transl. in 12mo., p. 159; Camper, *loc. cit.;* Flajani, *Nuovo methodo di medicare alcune malattie,* etc. in 4to., Roma, 1786.

every two or three days. Finally, Ravaton let the dressing remain until the twenty-fifth day, only beginning then to move the joint, and taking the important precaution of coaptating the fragments with the fingers while the movements were being made. The apparatus, being replaced, was again renewed every five days, and not finally left off until two months from the time of its first application.

Which of these three plans is preferable? The second unavoidably endangers weakness of the knee and all its consequences; the third is apt to interfere with bony consolidation; the first would certainly be the safest, if, on the one hand, it did not tend to cause stiffening of the joint, and if, on the other, it insured a closer contact and more perfect union of the fragments.

Now, as we have seen, the stiffening may result from one or more of these four causes: (1) the intensity of the inflammation; (2) the application of an apparatus during the inflammatory period; (3) the pressure of the apparatus; (4) the too prolonged immobility of the joint. By avoiding these causes, we can guard with certainty against their result.

The intensity of the inflammation is due either to the accident itself, or to the improper treatment employed. It may readily be allayed by rest, position, emollient poultices, and, if necessary, by blood-letting. It should be remarked that the elevation of the entire limb, which is the best position on account of the fracture, is also the most favorable for the resolution of the inflammation. Consequently, as soon as the surgeon is called to a fracture of the patella, he should lay the patient on his back in bed, making with a chair an inclined plane reaching from the buttock upward to the heel; upon this chair I would put a board six or seven inches in width, covered with a thick cloth several times folded, so as to form a kind of mattress for the limb, and having a foot-board, to prevent any motion of the foot from side to side. The leg is fastened to this board with a folded handkerchief, and the thigh with another; the knee is left to be covered with poultices, which should be frequently renewed. If from the degree of extension there is pain in the ham, this should be supported by means of compresses or a small pad; and general treatment should be adopted according to the grade of the inflammatory action.

It need hardly be said that it would be very imprudent to make use of pressure as long as any inflammation remains, and it is even well always to allow the first few days to elapse before resorting to any other means than position. Bromfeild opposes strongly the premature application of apparatus, which often gives rise, says he, to violent swelling, sometimes to suppuration, and even to gangrene. Sabatier, after at first following this injudicious practice, was so struck with its pernicious effects, that he went to the other extreme, and renounced the use of apparatuses of every kind. I have myself seen a figure-

of-8 bandage, applied on the first day, induce sloughing at the points of its greatest pressure; and M. Defer has published a case of gangrene brought on by the premature application of a starched bandage.

I shall not stop to notice undue pressure by the apparatus. But the duration of the treatment is of much greater importance.

Bassuel removed the apparatus by the twenty-fifth day; Verduc, from the thirtieth to the fortieth; Sir A. Cooper, on the thirty-fifth day in adults, on the forty-second in old persons; J. L. Petit, on the fiftieth; Boyer, after sixty or seventy days; and lastly, Dupuytren claims to have been the first to retain the apparatus for three or four months. The callus, whether bony or fibrous, being completed by the fortieth day, there is no advantage to be gained by keeping the knee any longer immovable; and there is a very serious inconvenience in the articular stiffening thus involved.

Now, by postponing the application of any apparatus until the subsidence of the inflammation, and by removing it, according to circumstances, from the thirty-fifth to the fortieth day, I have always seen the stiffening disappear readily in a short time. Such is therefore the rule which I should lay down, and which I follow.

But to obtain bony consolidation, it clearly results from what has been already said that the apparatuses hitherto employed are insufficient. I have therefore devised another, taking its *points d'appui* upon the bone itself without the interposition of the integuments, and acting upon the fragments in the same way as the twisted suture acts on the soft parts, except in not passing entirely through.

To make this instrument, take two steel plates, each an inch long and two-thirds of an inch wide, sliding upon one another, and this sliding regulated by a screw. The free extremity of each is bifurcated, and recurved into two very sharp hooks. The two hooks of the lower plate, only one-third of an inch apart, are intended to be inserted at the apex of the patella, which is lodged between them; those of the upper plate, which are to catch upon the base of the bone, may be separated by a space twice as wide; and the inner one should also be longer than the outer by one-sixth to one-fifth of an inch, to make up for the obliquity of this end of the bone.

The two plates being separate, I begin by passing in the two hooks of the lower one just below the point of the patella, only taking care to have the skin previously drawn somewhat downward. This done, I bring the fragments as nearly as possible into contact by pressure with my fingers; I have the skin covering the upper one drawn upward, in order that it may not be puckered into unsightly folds by catching in the interspace; now, committing the fragments so approximated to an assistant, I insert the upper hooks immediately above the base of the bone, until their points bear upon it as a *point d'appui*. Great force must be employed here, to pass in the points

as deeply as possible; I have satisfied myself by numerous experiments that it is impossible to go entirely through the tendon, and that there is much more reason to apprehend taking hold too superficially. The lower hooks pass completely under the edge of the patella, which is very thin at its apex, embracing this edge in their curve, and always becoming firmly fixed; but the upper ones have no purchase except upon the sloping surface at the base of the bone, against which they must be strongly pressed until the screw is substituted for the fingers, or they will slip.

The four hooks being properly placed, we approximate the two plates by sliding them upon one another, forcing them together by means of the screw. At first I made use of a simple adjusting screw, which, although very simple, I soon found to involve two disadvantages: first, the screw was left at the disposal of the patient; secondly, its working up or down required some force, and this gave the whole apparatus a twist, causing the patient much pain. M. Charrière provided each plate with an upright, bored horizontally for a screw, which of course plays parallel to the plates themselves, and may be worked by a key as in winding up a watch; and in this way the inconveniences mentioned are entirely done away with.

I have so far applied this apparatus in four instances, three of which were recent fractures. In the first, the hooks were inserted on the fifteenth day and left in place twenty-two days; I then perceived that the upper pair had slipped, tearing the skin; the whole thing was therefore taken off. The fragments remained separated by three or four millimètres; but their union was so firm that they did not move upon one another; flexion was entirely restored; the patient recovered his strength completely. To give some idea of this, he came to see me some months afterwards, having walked sixteen miles in nine hours, and expecting to walk six more to finish his day's journey.

The second case was that of a boy eleven years old; the hooks were inserted on the fourteenth day, and kept in place for an entire month. The result was as successful as possible; the fragments were completely united by bone, as far as could be made out in the living subject, and the knee regained its original mobility and strength.

In a third case, the hooks were inserted on the fourth day, began to slip on the twenty-first, and on the twenty-seventh were removed. At the outer side the fragments were firmly united, probably by bone; but internally there was some little separation.

Lastly, in a patient who had had for three months a transverse fracture, still ununited, and whose knee was extremely feeble, I attempted the application of the hooks, and kept them on for forty-one days; at first the fragments seemed pretty well consolidated, but in two days the separation was as wide as ever.

From the former of these cases we see how much success may be looked for in the judicious employment of this apparatus. Experiment has shown me at the same time two facts, equally unexpected; on the one hand the difficulty of adjusting the hooks, and on the other, their astonishing harmlessness when thrust through the tissues.

When I made my first attempt, I anticipated inflammation, suppuration, and perhaps a little necrosis, and did not calculate upon leaving the apparatus in place for more than ten days. I was happily surprised at meeting with nothing of the kind; there is not even any redness around the hooks, as long as they do not slip; and on their removal, cicatrisation ensues in two or three days.

But on the other hand, it is very difficult to fix the upper hooks firmly. M. Robert tried my plan at the Hôpital Beaujon; he could not approximate the fragments; and the patient dying from visceral disease, the autopsy showed that instead of catching upon the base of the bone, the upper hooks bore upon its anterior face, their points being engaged in the fibrous layer covering it. In my own attempts, when the accuracy of the coaptation showed that the application was properly made, it has been seen that the upper hooks were liable to slip at about the seventeenth to the twenty-second day. This is because they do not, as might be supposed, penetrate the substance of the bone; they are arrested, however great force we may employ, at its surface; and if this surface is sloping, like the base of the patella, they are only held by the tendinous fibres through which they have passed. After a certain period, these fibres become inflamed and softened by the pressure they sustain; and hence there occurs a slipping which makes it necessary to tighten the screw, or, if renewed, requires the removal of the whole apparatus. I have not hitherto succeeded in obviating this inconvenience, which is unattended with any risk, only affecting the exactness of the coaptation of the fragments and the closeness of their union.

Such is therefore my practice in all cases of transverse fractures with somewhat marked separation. When the separation is slight, sometimes mere position may suffice, with the addition of emollient poultices to allay irritation and muscular spasm. I have communicated to the *Société de Chirurgie* the case of a man cured in this manner, with bony union, of a direct fracture in which the separation had not been more than two millimètres. So also when the hooks have had to be prematurely withdrawn, rest, position, poultices, are still the surest means for completing the cure; in one case I tried substituting pressure for the hooks, but the little wounds became inflamed, and erysipelas supervened.

I shall not dwell upon the course to be pursued during convalescence; it is the same as in fractures generally. We should however make gentle but persevering attempts to restore as soon as possible the complete flexibility of the knee.

But we are not always called in in time, and I have been several times consulted by persons who in consequence of the laxity of the uniting band felt the knee give way under them in walking. Sir Charles Bell recommends that in all cases, in order to obviate the danger of falling, patients should be dismissed with a firm splint at the back of the joint, so as to prevent any yielding of the knee.* John Hunter was consulted by a lady, who in consequence of a fracture of the patella which had been left to itself, had lost the use of the limb, and could only move about by means of a wheel-chair. He advised her to move the leg frequently, by the force of her will aided by that of her hands. In three or four months the extensor muscles regained their action, and the patient could walk without any assistance. Sir A. Cooper succeeded in the same way with a woman who in consequence of breaking both patellæ had lost the free use of both legs.

Here then are two very different lines of practice. It seems to me that we give them their true position in regard to one another, by saying that in the cases treated by Hunter and Sir Astley Cooper there must have been a necessity, after the cure was complete, for the posterior splint of Sir C. Bell. But some surgeons, with greater boldness, have conceived the idea of freshening up the fractured surfaces, and then bringing them together again.

Severinus proposed, in a case of this kind, to lay bare the fragments by an incision, and then to make a new surface to each; which plan was fortunately not carried into execution.† But it is said that Dieffenbach, some years since, made a subcutaneous section first of the ligamentum patellæ, and afterwards of the tendon of the rectus femoris three inches above the joint, so as to avoid the synovial cavity; after which, having rubbed the fragments together, he kept them in contact by means of an apparatus for parallel pressure, and obtained a new union with very marked impovement.‡ I doubt the accuracy of these details. In the first place the section of the rectus femoris tendon would be quite useless unless the other portions of the quadriceps extensor were divided also; secondly, the performance of section of the ligament, in addition to that of the muscles, is incomprehensible; thirdly, these two sections would give rise to infirmity quite as troublesome as that from a badly united fracture; in a word, I should consider such an operation wholly unjustifiable. I once attempted for forty days, as was before stated, to bring together the fragments in a fracture of three months' standing, without any satisfactory result. Perhaps it would have been proper here to freshen up the surfaces with a tenotome introduced subcutaneously, before endeavoring to make the coaptation. Apart from this last

* *London Medical Gazette*, 1827, vol. i, p. 25.
† M. A. Severinus, *Chirurgiæ efficacis*, part ii, cap. vii.
‡ *Gazette Médicale*, 1841, p. 780.

resource, the simplest and surest plan is to make the knee immovable by means of a hollow splint beneath the ham.

If walking is interfered with by extreme stiffening, giving pain upon the slightest motion, I should advise a resort to a similar splint.

§ II.—*Vertical* [*Longitudinal*] *Fractures of the Patella.*

Fractures of this form are the rarest of all; but I allude to them here because their examination will aid us in studying the multiple variety.

Guillaume de Salicet was the first to mention them; but we must come down to Van der Wiel and Delamotte to find instances quoted;* and Sir A. Cooper and Dupuytren are the only surgeons who have given special attention to the subject.

These injuries are caused by falls on the knee, or by direct violence acting on the patella. Dupuytren saw one which was due to the passage of a carriage-wheel over the knee; Cousté, one produced by a splinter from a gun-carriage striking the patella of an artilleryman.†

They present several varieties. In the first place, some fractures which are properly oblique are called vertical, as may be seen in Sir A. Cooper's plates. Again, they are distinguished according as the bone is divided into two nearly equal portions, or only one-third or even one-fourth is separated. We find in Daniel Turner's work the history of a much more remarkable form, if the diagnosis were only more clearly made out; a girl thirteen years old struck her knee against a door, and sustained a considerable contusion; an abscess supervened, and a portion of the patella came away, which was regarded by three surgeons as having been detached by a fracture. This fracture had divided the bone nearly vertically, but from side to side, without entering the joint; this case is hitherto unique, but the meagreness of the essential details unfortunately leaves room for doubt whether it was not merely a case of necrosis.‡

Lastly, Sir A. Cooper states that in 1822 there was dissected at St. Thomas's Hospital the body of a man, who had a vertical fracture of each patella.

Besides contusion, pain, swelling, and all the general symptoms, the distinguishing feature of these fractures is the lateral separation of the fragments. In Van der Wiel's patient this was sufficient to allow of the introduction of the little finger; in Delamotte's it was two good fingers'-breadths wide. It may be seen to increase when

* Stalpart Van der Wiel, *Observat. rariores*, 1687, obs. 97; Delamotte, *op. cit.*, obs. 366.

† Cousté, *Thèse inaug.*, Paris, 1803, No. 22.

‡ Turner, *Art of Surgery*, fifth ed., vol. ii, p. 273.

flexion of the knee is attempted; it is diminished in extension, and the two fragments may be brought in contact and rubbed together so as to elicit crepitation.

This singular separation has been a matter of surprise to surgeons. Dupuytren declares that the muscles have no tendency to produce it; Sir A. Cooper thinks that they rather lessen it; and from some experiments on rabbits, he infers that it is the condyles of the femur which when the knee is flexed press the fragments away from one another. But besides that this theory could hardly be sustained in regard to man, extension, even when most complete, still leaves the fragments separated. Sir Astley's last experiment especially should have undeceived him. Having divided the patella crucially, the two lower fragments were not displaced, and united by bone; the two upper ones remained apart, and became connected only by fibrous tissue.

I think that here we must recognise muscular action. If we study this region in man, we find the fibres of the vastus externus, running very obliquely as compared with those of the rectus, going to be inserted by a common tendon into a special facette at the outer angle of the patella; the fibres of the vastus internus, less oblique indeed, are attached to the whole inner edge of that bone, even reaching as far down as the tibia. But if the patella be divided into two lateral portions, these will be drawn apart by the action of these powerful fasciculi, which antagonise one another; which shows why the separation is greater the more these muscles are stretched, as in flexion of the leg; why it still exists in extension, unless the preservation of the fibrous tissues interferes directly with the traction of the muscles; and why, lastly, when the fracture is cruciform, the two upper fragments are still drawn apart, while the lower ones are not separated, but drawn aside together if the vastus internus continues to act, the vastus externus having lost all its power over the outer one.

There is therefore here, as in the transverse variety, a muscular contraction holding the fragments apart, and thus tending to prevent bony union; so that, in all cases in which the state of things has been investigated by dissection, the callus has been fibrous. It may easily be seen that if the fibrous tissues covering the bone escape division, the fragments will be held together, and will unite by solid ossific deposit; and this Sir Astley Cooper verified by special experiment.

The prognosis should therefore be to a certain degree reserved; but it does not appear that the fibrous character of the union need impair the functions of the limb at all.

The treatment reduces itself to this one grand indication, to oppose the action of the muscles, in order to approximate the two fragments. The leg should consequently be put in complete extension, but it is

not worth while to elevate the heel, since the rectus muscle exerts no unfavorable influence on this fracture. The inflammation being subdued, it will be well to employ some apparatus for making pressure, in addition to mere position; Sir A. Cooper advises putting at each side of the patella a pad, and bringing the two together by means of a laced knee-cap and two straps, one above and the other below. Perhaps this apparatus is rather complicated, and the same end would be as surely attained by laying two simple graduated compresses along each side of the bone, and drawing them together by strips of lead-plaster.

§ III.—*Multiple Fractures of the Patella.*

After what has been said in the two foregoing sections, but little need be said to complete the history of multiple fractures.

These are always due to a fall on the knee, or to a direct blow. Most commonly they are double, the upper fragment of a transverse fracture being divided; I have recently seen a case of this kind. Sir Charles Bell met with another form, consisting in a longitudinal fracture near the inner edge of the bone, the outer fragment being in its turn divided across. I have reported an instance of two transverse fractures of the same patella, but not produced at the same time. More numerous fractures are rare; thus I know of no example of a triple division of the bone. Sir C. Bell has had represented a patella broken into five pieces; a still more comminuted fracture may be found in *Fig.* 83; and these are the only instances I can cite.

Ecchymosis is in these cases very common, and the swelling is generally considerable. Still, probably by reason of the soundness of the fibrous envelope, the separation is apt to be less than in transverse fractures; and Camper, Sir Charles Bell, and Gulliver have shown that bony consolidation is also more frequent. Facts observed only during life are, it is true, of but little value; but autopsies are not wanting; Sir Charles Bell states that he examined four patellæ fractured by direct violence, in which osseous union had occurred in various degrees; and he showed at his lectures the one spoken of as broken into five pieces, agglutinated and held together by masses of coagulable lymph, which was already ossified at several points. In all these cases the inner surface was sound, except that the cartilage was divided; the callus gave rise to irregularities only on the anterior face of the bone, which in the specimen last mentioned, for instance, showed masses of lymph and ossific deposit like those met with in fractures of long bones.

These fractures are recognised either by the mobility of the frag-

ments, or by their separation, rendered evident by the increased width of the bone.

In double fractures, with three fragments, if the vertical division is seated in the upper portion, we must look for some separation by muscular action, which however will not interfere with the functions of the limb. It would seem, on the contrary, that no separation attends vertical division of the lower fragment.

As to the treatment, we must pay attention mainly to the transverse fracture, taking care also that the separation in the other does not become excessive; if the fragments remain in contact, we need only insure the proper position of the limb, moderating the inflammation if necessary.

CHAPTER XVIII.

FRACTURES OF THE BONES OF THE LEG.

Of all fractures, these are the most common; including those involving both bones and those involving only one, they constitute 652 out of our whole number of 2328 single fractures, while among the thirty patients with multiple fractures, the leg was broken in twenty-six. According to this, they form more than one-quarter of all the fractures met with in practice.

We distinguish first, fractures of both bones,—fractures of the *leg*, properly speaking; fractures of the tibia; and fractures of the fibula. We shall study separately fractures just above the malleoli, and those seated at the malleoli.

Fractures involving both bones are the most frequent; then come those of the fibula, and lastly those of the tibia. Of the first there are found in my summary 515; of the second 108; of the third only twenty-nine. I cannot say that these figures express the exact relative frequency of the varieties; thus under the head of fractures of the leg there may have been placed some fractures of the tibia alone; and certainly the estimate is too low as regards fractures of the fibula. But I shall refer to this question again hereafter.

§ I.—*Fractures of the Leg.*

These are very rare in early infancy; of the 515 cases, but one was as young as four years. From five to fifteen, there are only twelve; so that there seems to be during childhood a sort of antagonism between fractures of the leg and those of the thigh.

The number increases rapidly after the fifteenth year; from that to the twenty-fifth, for example, we find fifty-seven. From twenty-five to thirty-five years the number nearly doubles, and holds its own after that until about the age of sixty. Between sixty and seventy it falls to sixty-one; from seventy to eighty we find only twenty-two, and there are only four in persons over eighty.

Men would appear to be twice as liable to this accident as women: 344 to 171. But this proportion is by no means the same at

all periods of life. Thus from infancy to fifty years of age, there are 234 males to 74 females,—three to one. From fifty to seventy-five, the two sexes approach one another remarkably,—there are only ninty-seven men to eighty-six women. Lastly, beyond seventy-five years, the women notably exceed the men—being as eight to three.

The influence of cold weather is quite marked; the summer season affords but 201 fractures, while 314 occurred during the winter.

The determining causes are direct or indirect. The former are perhaps a little more frequent than the latter; I have traced them in thirty-six cases out of sixty-seven. Sometimes a carriage-wheel passes over the limb; sometimes a heavy body, such as a mass of building materials, a beam, a falling bank of earth, etc., may come down upon the leg from a variable height; or perhaps a violent blow, such as the kick of a horse, is received while the patient is standing up, and the fall is consecutive to the fracture.

Among the indirect causes, the most common seems to be a simple fall on the pavement, from a false step; of my thirty-one instances of indirect fracture, ten were so produced. If to these falls are added those sustained in running, or in struggling, whether the patient slips, or a stick is thrust between the legs, or the foot is twisted in a rut, we have a proportion of eighteen out of thirty-one, due to falls from the erect position. The rest are owing to falling from greater heights, as down a staircase, from a ladder, a scaffolding, or a roof, etc. In one unique case, the patient was falling from a ladder, when his leg caught between two of the rounds, and was thus broken by an altogether peculiar mechanism.

In studying the influence of these causes upon the seat of the injury, I have arrived at quite curious results. Among my thirty-six direct fractures, the exact locality is omitted in one; eighteen were in the middle portion of the leg; two only were higher up, near the knee; six at about the lower third; eight somewhat lower down, an inch or two above the malleoli; and one was double, affecting the upper as well as the lower third. Does not this very large proportion of fractures at about the middle of the leg authorise the presumption that some of them were the result of counter-stroke, and seated at a different point from that at which the blow fell? It would be hard indeed to conceive that carriage-wheels should so often pass exactly over the middle of the leg.

Indirect fractures seem to choose a very different seat. Of my thirty-one cases, in one the exact point is not designated; in twenty-one, the tibia was broken somewhere in its lower fourth, more or less close to the malleoli; in three, in its lower third, and in six at its middle.

According to these figures, fractures of the upper third, which are very nearly the rarest of all, would be due solely to direct causes;

those about the middle, of much more frequent occurrence, would find their principal causes in blows or great pressures; and lastly those in the lower third, the most common of all, should be ascribed more especially to indirect violence. There is thus a remarkable analogy between fractures of the lower extremity of the leg from falls on the feet, and those of the lower extremity of the radius from falls on the hand.

Each order of causes is attended also by complications, more or less numerous. Of my thirty-one indirect fractures, only nine communicated by wounds with the external air, while of thirty-six from direct violence, eighteen presented such a communication. In the latter the wound is due to the external violence, and takes place generally from without inward; in the former, on the contrary, it is ordinarily one of the fragments of the tibia, and almost always the upper one, which pierces the integuments from within outward. The height of the fall has something to do with this disastrous complication, but we should not ascribe to this an undue influence. Three men, who had fallen upon their feet from a height of twenty-five or thirty feet, had fractures without any external wound; four others, from simple falls upon the ground, sustained compound fractures of such gravity, that two of them died.

Besides the differences resulting from their causes, seat and complications, fractures of the leg vary also according to the disposition of the fragments. In the first place, it is quite rare for the two bones to give way at the same level; this only occurs in fractures from direct violence, and even in these the fibula is often broken either higher up or lower down than the tibia, or in both points at once. As for indirect fractures, in them the seat of injury in the fibula is almost always two or three inches above that in the tibia.

I have elsewhere (page 67) mentioned how some surgeons may have been misled in regard to the occurrence in the tibia of fractures *en rave*, and it is unnecessary to repeat what was there stated. Fractures of the leg present themselves therefore as serrated, oblique, splintered, comminuted and multiple; and the same remarks apply to either bone; only that as the tibia is the more superficial and the larger of the two, our observations are directed almost entirely to it.

Oblique fractures of the tibia vary much in the degree of their obliquity. Some divide the bone in a direction nearly transverse; others are almost longitudinal, and the fragments are sharpened, as the expression is, into a very long *bec de flûte*. In general the line of fracture runs downward and inward, (see *Figs.* 88, 89, 90;) often also it passes downward and forward, (*Fig.* 86;) very rarely it takes the opposite directions; I have however represented in *Fig.* 87, a fracture running from above downward and backward; and there have been seen fractures which were oblique downward and outward. It must be added that these expressions are only approximative; that

the most marked obliquity in any one direction almost always encroaches more or less upon some other face of the bone; and that, strictly speaking, the most common of all forms of oblique fracture is that which runs downward, inward and somewhat forward.

Splintered fractures present far more numerous varieties of form. The most usual is that already spoken of, (page 73,) an example of which may be seen in *Fig.* 7. Here we see a wedge-shaped piece detached from the outer face and anterior edge of the bone, and squeezed out toward the fibula by the approximation of the two fragments from which it has been separated. I have more than once observed in the living subject such a splinter, displaced in this way, remain prominent and movable in the interosseous space, even after the two portions of the tibia were united by solid callus. I would also call attention to a form of splinter peculiar to very oblique fractures of the tibia; its line of division runs parallel to that of the main fracture, for a distance of two or three inches or more; and it often gives rise to suppuration which can only be checked by its extraction.

The general symptoms of fracture, contusion, swelling, pain, mobility, crepitation, etc., are here present in a very marked degree, and the diagnosis is rarely obscure or uncertain. There is besides commonly more or less displacement, rendering the nature of the case perfectly evident. Still, in those rare instances in which the fragments remain interlocked, or in which an obstacle to angular deformity is presented by the difference of level of the points of division of the two bones, there occurs a very remarkable phenomenon, which of itself would suffice to attract the surgeon's attention; this is starting of the limb, taking place at intervals through the night, and violent enough to awaken the patient. From this one symptom I should not hesitate to infer the probability of one of the bones at least being broken, more especially the tibia, and to adopt all the means necessary to place it beyond doubt.

Fractures of the leg are subject to all the varieties of displacement. In the first place they may be transverse, or in the direction of the thickness of the bone, rarely complete as regards the tibia, almost always so in the fibula in case of overlapping; generally it is the upper fragment of the tibia which is carried forward and inward. Then comes angular displacement, occurring at the outset from the fracturing cause, from the weight of the limb, in a word, from some external agency; and subsequently kept up or even increased by muscular action. It is chiefly the muscles of the calf, acting on the calcaneum, and by it on the lower end of the lower fragment, by which this latter is drawn backward, so as to form with the upper one an angle more or less salient anteriorly. I have seen a case of this kind in which union had taken place with the two fragments at a right angle; in another, an account of which is given by M. Josse

of Amiens, the angle was an acute one.* Different conditions of the fracture may affect the direction of this angle; for instance, in fractures just above the malleoli, which will be examined separately, it is more commonly salient inward than outward.

Displacement by rotation, or in the direction of the circumference, may be due to the external violence, or perhaps to eversion or inversion of the foot by its own weight; but usually it results from unintentional movements of the patient, or from the pressure of the bedclothes.

Overlapping is hardly met with except in oblique fractures, in which it is almost constant. Sometimes it is produced in an inordinate degree by the fracturing cause; as in falls from heights upon the feet, the upper fragment of the tibia has been seen to penetrate the muscles and skin, and even to bury itself in the ground. In other instances, the force being less, it merely projects under the skin, distending and threatening to rupture it; but generally the overlapping is very limited, the thickness of the tibia scarcely allowing the fragments to completely abandon one another, the interosseous ligament serving also as a check if necessary, and lastly, perhaps from the fact that most of the muscles of the leg are attached along the entire length of both bones.

But there is one other form of displacement, hitherto confounded with transverse displacement or with overlapping, and deserving of special attention, namely, the separation of the fragments. I have just said that in some cases of overlapping, the point of the upper fragment stretches the integuments and threatens to pierce them; and indeed, by glancing at most of the drawings from No. 85 to No. 90, we see that the lower fragment in a case of oblique fracture cannot go up along the upper one, without forcing the latter either to one side or the other. But besides this mechanism, which is due to the muscles of the leg, there is another agency drawing the upper fragment directly away from the lower, and making its point project forward; this is the contraction of the muscles inserted into the patella. In fact, if the muscles of the leg alone are acting, the projection forward of the upper fragment may be overcome by position, and especially by permanent extension. Now if we try flexing the limb with the view of relaxing the muscles, the prominence increases; if we make sufficient traction to obviate the overlapping, the prominence diminishes, but does not entirely disappear; on the contrary, it is in all cases diminished, and in some completely effaced, if to a sufficient degree of extension is added strong pressure over the salient point; and the influence of such pressure is so marked, that no doubt can remain as to the action of a force tending to raise the fragment in question, and to separate it from the lower one.

* *Journal de Chirurgie*, Oct., 1846.

The course of fractures of the leg is very simple, when there is no displacement, or when the displacement, transverse or rotary, is but slight, even though there may be overlapping. The callus forms in thirty-five or forty days; and we may take off the apparatus and let the patient move his limb in bed without any inconvenience resulting. But it is otherwise with oblique fractures, when the upper fragment projects. Even when this fragment does not threaten to pierce the skin, the separation of the broken ends presents the same obstacle to consolidation, in a different degree, which is met with in fractures of the patella. If we take off, at the end of forty days, any ordinary apparatus, the patient cannot move the limb without experiencing at the seat of injury pains, which almost certainly indicate that consolidation is imperfect; and in two or three days afterwards, the mobility will often reappear; in one of my patients, who had been eighty-four days in the hospital, the callus gave way several weeks later, from a very slight movement.

Dupuytren was struck with the weakness of the callus in these cases of oblique fracture; besides the pains, mobility, and deformity, and the pseudarthrosis so common after fractures of this kind, he pointed out a consecutive shortening of the limb, which he ascribed to yielding of the callus under muscular contraction. Hence, judging that the definitive callus alone was capable of resisting this force, he came to the practical conclusion that in oblique fractures it was necessary to keep on the apparatus for three months.*

I have stated already (page 126) my views as to this theory. There is no provisional callus here, any more than elsewhere; when the limb becomes shortened, it is because bony union has not occurred; and it is not only the muscles, but the weight of the limb, and especially that of the body in walking, by which the immature callus is strained, and loses its firmness. By exerting sufficient pressure on the separated fragments, however oblique, I have more than once obtained perfect consolidation in less than forty days.

Splintered and comminuted fractures are subject to the same risks, and from the very same cause. They eventually unite, but with stiffening of the neighboring joints in proportion to the length of the treatment, and nearly always with deformity; while if we try to shorten the period, we endanger the formation of a false joint. If, on the contrary, the fragments have no tendency to separate, consolidation occurs without difficulty, but never so rapidly as in single and serrated fractures.

I shall not dwell here upon the course of compound fractures, but refer the reader to the general discussion of that subject. Only, the great obstacle to union here is still the mobility and especially the separation of the fragments; so that if we can succeed in fixing

* *Leçons Orales*, second edition, tome i. p. 36.

them by suitable pressure, we may obtain almost as speedy a cure as in a simple fracture.

The method of consolidation presents nothing special, when the fragments have remained or are replaced in contact; each of the fractures unites by itself, and the bones are restored to their usual condition. But when one of the fragments of the tibia is carried toward the fibula, or the reverse, osseous deposits take place so as to connect one bone with the other, sometimes at one point only, sometimes at two or three; and by these the play of the tibio-fibular articulations is manifestly destroyed. (See *Figs.* 88, 89, and 90.) In one specimen in the Musée Dupuytren (No. 135) the two bones are soldered together at the level of the fracture, and as a consequence complete anchylosis has occurred at their lower junction.

The diagnosis may generally be made out with the greatest ease, especially in regard to the fracture of the tibia. That of the fibula is detected most commonly by the mobility and displacement of the tibia, rather than by any symptoms of its own; and it is but rarely that we can recognise its precise seat, or the arrangement of its fragments. This, however, is of but very slight consequence.

The prognosis is very simple unless there is displacement. But when the fracture is oblique, or comminuted, and gives rise to a persistent prominence, the prognosis rests essentially upon the plan of treatment adopted; and a patient may remain crippled, or even lose his life, from a badly managed fracture, which a more enlightened surgeon would have cured as readily as any ordinary case.

In order to accomplish reduction, when no very great power is required, an assistant holds the knee, grasping it with both his hands; another takes the heel between the thumb and fingers of his left hand, and puts the four fingers of his right hand over the metatarsus, the thumb coming under the sole, so as to pull on the foot, keeping it at a right angle with the leg; care should also be taken to have the inner edge of the great toe in the same vertical plane with that of the patella. When two assistants are insufficient, a handkerchief should be tied below the knee, or even a loop passed around the groin of the injured side, to make counter-extension, and a handkerchief made into a cravat tied around the foot to make extension; the two ends of this may be drawn upon by any number of assistants that may be requisite. The mode of applying it is not unimportant. When there is only a simple lateral displacement, its middle portion is passed beneath the tendo-Achillis, and its ends are crossed over the instep; but if the fragments present an angle anteriorly, such an arrangement would only increase the deformity. We then simply shift the centre of the cravat to the front, tying the ends behind in a single knot; traction made upon these will have the effect of elevating the heel, and depressing, by a kind of lever movement, the lower fragment. But the best way to fasten the cravat is to

make one knot opposite one malleolus, and then carrying one end under the tendo-Achillis, to make a second knot on the other side; we thus form two lateral loops, by means of which traction may be made almost exactly in the line of the axis of the limb.

I have elsewhere described, in a general way, the method of making coaptation; only the surgeon should recollect that it is not always so easy as it is said to be to reduce transverse displacements, even when very slight.

When there is no displacement, or when the displacement has been reduced and does not tend to reappear, we may make use almost indifferently of any contrivance, splints, boards, cushions, immovable apparatus, etc. It is well, however, to remember that by the inclination of the foot the lower fragment may be rotated outward; that the weight of the lower portion of the limb, aided sometimes by the pressure of the bedclothes, may cause the heel to sink into the cushions, making the fragments form an angle salient anteriorly; lastly, that the most perfect reduction of a fracture cannot prevent its derangement by untoward movements of the patient. It is therefore necessary, whatever apparatus may be employed, that the foot should be kept at a right angle with the leg, and free from any lateral deviation; that the surface supporting the limb should be sufficiently firm; and that suitable pressure should be made at each side to maintain reduction in spite of any slight inadvertence of the patient. It may be added, finally, that a slight degree of flexion of the knee is more comfortable, as well as more favorable to the relaxation of the muscles and the suppleness of the articulations.

The immovable apparatus fulfils perfectly all these conditions, and presents but one disadvantage, namely, that it conceals the parts, and deprives them of the benefit of exposure to air and light. This evil is done away with by M. Scutin's plan of dividing it, and on the whole, in patients of good constitution, when all danger of inflammation is past, I make use of it without hesitation; in young children I prefer it to any other. But except under these circumstances, I consider it safer to employ splints, which leave the fracture open to observation, while retaining it in position. The limb being then placed upon a double inclined plane, or the leg alone supported upon cushions arranged on a firm board, I pass under it a splint-cloth as wide as from the knee to the heel; in this is rolled on each side a broad firm splint reaching a couple of inches beyond it above and below. Two stuffed bags [junk-bags] of the same length are laid along the leg, one on each side, to moderate the pressure of the splints, which are held in place by means of three bands. Finally, a short strip of bandage surrounds the sole of the foot, its ends crossing one another over the instep, and going to be fastened with pins to the splint-cloth. By this method the whole anterior portion of the leg is left open, ready if necessary for the application of poultices; and if the appa-

ratus becomes loose, we have only to tighten up the bands, without deranging anything or moving the limb.

When there is transverse displacement, it is necessary to act upon the fragments by pressing them into position, or at least to prevent their further derangement. The splints answer this purpose exactly; we may increase the thickness of the padding at some points, and diminish it at others, or we may apply *immediate* splints beneath the principal ones. Advantage may also be derived from the employment of a cravat placed around the limb at the point of projection, and tied over the splint on the opposite side; but care should be taken lest this compression should cause mortification of the integuments.

Angular displacement may be treated in the same way, but with the same precautions. When the fragments incline backward, which is rare, we may endeavor to raise them by lowering the heel; in place of keeping the foot at a right angle with the leg, we should press upon the instep by means of a cravat, previously passed beneath the malleoli. On the contrary, when the angle is salient anteriorly, the heel and toe should both be kept well up; the flexion of the knee should be increased; compression should be made in front of the leg by means of a pad and splint, or with a cravat tied under the sustaining board; and we may likewise try permanent extension. These plans may be variously combined, or they may all be employed at the same time, before resorting to more powerful means.

[In the Pennsylvania Hospital, the great majority of fractures of the leg are treated by means of the *fracture-box*. This may be of any size to suit that of the limb affected. It is formed of a bottom-piece, reaching from the ham to below the heel; a vertical foot-board of sufficient height to prevent the weight of the bedclothes from bearing upon the toes; and two sides hinged to the bottom-piece. The foot-board is provided near each lateral edge with a mortise, three or four inches long and half an inch wide. In order to use this apparatus, three strips of rather wide bandage, and a soft pillow of a square form, are required. Two of the strips are laid on the bed, a few inches apart; across them is placed the fracture-box, with its sides turned down, and the pillow upon it. The third strip being applied by its middle over the tendo-Achillis, and its two ends crossed over the instep, the limb is laid in proper position upon the pillow. The two ends of the third strip are passed through the mortises, and tied on the outer surface of the foot-board, so as to keep the foot upright against the latter. Now the sides of the box being brought up, the pillow may be so arranged by pressure as to exactly fill up the interspaces between the limb and the box, and the whole is completed by tying the first-mentioned strips so as to keep the sides up as closely as may be required. Any points especially exposed to pressure may be protected by lint or raw cotton, or compresses may be employed if the pillow does not bear sufficiently upon any part of the limb.

A box of this kind may be put together in a very short time; and there is nothing equal to it when a patient with a fractured leg is to be moved from one place to another. In such cases the hinges, although convenient, are not indispensable; so that the only really necessary materials are the boards and nails; straw may be arranged so as to answer instead of a pillow, and wisps of straw may in case of need be used instead of the confining strips of bandage.]

Permanent extension is applicable also in cases of overlapping; but as this is generally very slight, it suffices for the most part to fasten the foot to the foot-board of the inclined plane, while a loop in the groin connects the body with the head of the bed. If the overlapping is more marked, we may take our choice among the methods of extension described in the chapter on general treatment. I shall, however, mention one plan recently proposed by M. de Saint-Martin, which is both simple and convenient.

His apparatus consists of two splints, of a length somewhat exceeding that of the leg, unconnected at their upper extremity, but fastened below to a cross-piece keeping them at a proper distance apart; holes are bored in this cross-piece at each side, for the passage of the extending loops, and in its centre another one for a wooden screw, which should play freely. The thread of this screw fits a hole in another cross-piece, unattached, and moved toward or away from the first one by turning the screw. To afford a *point d'appui* to the upper ends of the splints, a knee-cap of ticking is fitted on, having at each side a socket; into these sockets the ends of the splints are inserted. A small gaiter of the same material is laced over the malleoli and instep; to this are attached the extending bands, which pass through the holes in the first cross-piece, and are fastened to the second or movable one. It may easily be seen that by turning the screw so as to separate the two cross-pieces, traction may be made on the extending bands to any desired extent; and that the two splints, being pushed upward by the same mechanism, but prevented from yielding by the sockets of the knee-cap, tend to carry upward the knee, and with it the upper fragment.

I have sometimes used this apparatus with advantage, especially in compound fractures; these are left so exposed that they may be examined and dressed without any derangement. It has the drawback of exerting considerable circular pressure upon the integuments of the knee and over the malleoli; the effects of this pressure may be obviated by wadding, but at some loss of tractile power, that is, of force to overcome very obstinate overlapping. The knee-cap, however loosely applied, has the still more serious inconvenience of obstructing the venous circulation; and in one case of extremely complicated fracture, which I could not keep in place by any apparatus, I had to abandon it, on account of the very troublesome engorgement to which it gave rise, involving the entire limb as well as the

wound. Renaud, in 1812, contrived one almost similar to this; only in place of a knee-piece, a strap was buckled around the thigh, with two leather sockets for the splints; the strap and gaiter were both made of leather, softly padded with wool.* I doubt whether the retardation of the venous blood would be any less from constriction of the thigh than from that of the knee.

[A very simple method of making extension may be readily adapted to the fracture-box before mentioned; the first publication of it was made by Dr. Neill of Philadelphia, in 1855. The box should be made to reach somewhat higher than usual, and a hole should be bored in each side near its upper end. Extension may be made with adhesive plaster, precisely as in fractures of the thigh, (see *ante*, p. 585,) the lateral strips reaching up as far as the seat of fracture. Counter-extension may be made with adhesive strips, fastening them to the limb just as for extension, and connecting them to the splint either immediately, passing their ends through the holes above mentioned, or by means of strips of bandage; this latter may be readily and neatly done by wrapping the end of the adhesive strip around a bit of strong stick, and cutting a longitudinal slit in the strip, through which to pass the piece of bandage. Another way of making counter-extension is by laying a piece of bandage on each side along the upper part of the leg; binding them in place by means of circular turns, and then bringing up the lower ends and passing them through the holes, tying together the corresponding ends as firmly as may be judged expedient. The former is the preferable plan.]

But the fractures least manageable by the forms of apparatus hitherto in use are undoubtedly such as are oblique, with separation of the fragments and projection of the upper one.

Pott was the first, if I mistake not, to write concerning the cause and treatment of this projection. He relates that an English surgeon, whose name he does not give, invented a machine for correcting it, modeled on J. L. Petit's tourniquet. Pott disapproves of trying to push in the prominent portion; according to him, the only rational plan is to raise up the lower fragment to the level of the upper; the lateral decubitus, and semiflexion, always sufficing for this. Dupuytren defends Pott's views in this respect, but as his success with the lateral decubitus was far from being constant, he thought it proper to modify the position according to the direction of the obliquity, and proposed this general rule:

"When the obliquity runs from one side to the other, the limb should rest, semiflexed, upon its posterior face; when the obliquity runs from before backward or from behind forward, it should lie on its outer face."

* Renaud, *Observ. sur une fract. comminutive de la jambe droite, suivie de tétanos*, Grenoble, 1812.

Boyer is strangely silent on this point, and advocates the extended position of the limb. M. Ph. Boyer, although a faithful observer of his practice, has deemed it right to deviate from it in the case in question; he does not hesitate to advise putting the limb in semi-flexion, and on its outer side. M. Mayor, returning to the oldest idea of all, has proposed compressing the upper fragment by means of handkerchiefs widely folded, and M. Laugier has resorted to section of the tendo-Achillis. Such was the state of the question when I took it up.

Every one knows that if the limb is kept stretched out, it is in the immense majority of cases impossible to overcome the projection of the upper fragment. Should we succeed better by following Pott's advice in regard to position? The best proof to the contrary is, that Dupuytren was obliged to modify it. But even with his modifications, was he certain of his results? I have seen him apply his method in a perfectly simple oblique fracture; it solidified with a marked prominence.* As for compression exercised upon the upper fragment, either with handkerchiefs or with the tourniquet, it rapidly induces gangrene of the integuments; the surgeon spoken of by Pott, having employed his machine in a case of simple oblique fracture, only converted it into a compound one; and I have cited other analogous cases. As for section of the tendo-Achillis, M. Laugier himself confesses that it did not entirely correct the projection; it moreover gave rise to an abscess, followed by burrowing of pus, and finally by the death of the patient.†

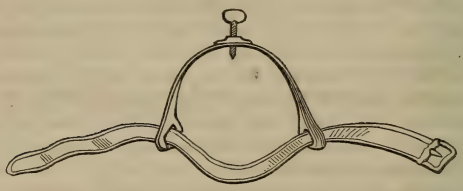
This then is the question which presents itself: what is the result in oblique fractures with projection, since remedies are so powerless? In the first place, in a certain number the projection is but moderate, and is allowed to remain, the patient having only to wait three or four months for complete consolidation to occur. If the prominence is more marked, the callus formed exhibits a notable degree of deformity; the point of the bone distends the skin, which is thinned and threatens to ulcerate. I have elsewhere (page 278) mentioned the case of Meyranx, in whom ulceration and almost constant pain were kept up until death, by a projection of this kind. Too often also the fragments unite at an angle, and an irremediable limp is added to the deformity. Lastly, sometimes the projection cannot be corrected; the point of bone irritates the skin, and protrudes through it by inducing mortification; the only resource of art is then to resect the broken end, unless the case should assume a still more serious aspect. I have seen the skin thus perforated, and the patient reduced to such a state as to necessitate amputation of the thigh. As for vicious consolidation, I saw so many cases of it at Bicêtre, that I

* See the *Gazette Médicale*, 1832, p. 39.
† Laugier, *Bulletin Chirurgical*, tome ii, p. 253.

at last left off collecting them; and they came from nearly all the hospitals in Paris.

It was in 1840 that I first had to contend with difficulties of this sort. An insane patient had broken his leg by a fall, and the upper fragment, very sharply pointed, threatened to pierce the skin. I tried different forms of apparatus and different positions; I should note here that great elevation of the limb succeeded a little better than the other plans. I inclosed the part in a plaster mould; the upper fragment was tilted up so strongly as to crush, as it were, the integuments against the plaster, and I was compelled to abandon the attempt. It was evidently requisite to make firm and constant pressure on the fragment, and yet not to bear upon the integuments; and in view of this necessity I devised my screw apparatus.

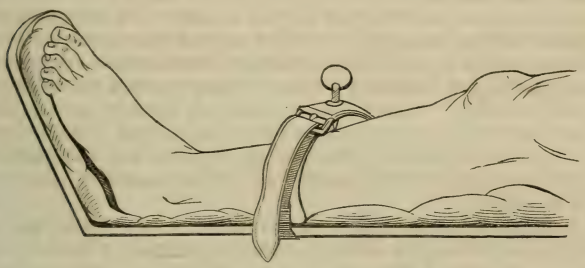
This is made of a sort of bow of strong sheet-iron embracing the anterior three-fourths of the leg, leaving an interspace of a finger's-breadth between it and the surface; at each end of this bow is a



horizontal mortise; through this there is passed a strong silk or cotton band, with a buckle at one end; and lastly, at the centre of the bow is a solid nut, through which plays a very sharply-pointed screw, for making the pressure. (See cut.)

In applying this machine, I place the limb on a double inclined plane, properly padded with wadding or linen, taking care that the angle of the apparatus answers exactly to the ham, or is even a little above it, so as never to let it bear against the upper fragment. Another and no less essential precaution is to arrange beneath the tendo-Achillis a sufficient thickness of padding to prevent the heel from being directly rested upon. Extension and counter-extension being duly made by assistants, the instrument is applied as follows: the free end of the band, withdrawn from the mortise at that end of the bow, is passed beneath the inclined plane just at the level of the point at which pressure is to be made; it is then passed through the mortise again; the other extremity is then applied above the bow, the screw being let into a hole in the band, near the buckle. The bow is adjusted over the limb, and the band passed through the

buckle, ready to be tightened. The surgeon now makes coaptation as exactly as possible, keeping it up by pressing upon the upper fragment with the fore and middle fingers of the left hand; he fits the bow and its screw so that the latter shall strike the fragment in the precise direction requisite, still preventing by means of his two fingers its unnecessarily lacerating the skin. He now tightens the band as much as possible, and rapidly turning the screw, drives its point without hesitation through the skin and into the inner face of the bone, increasing the pressure to any degree he may think proper. It is better that the instrument should act nearly or quite two inches, at least, from the seat of the fracture.



The patient experiences at the moment of the puncture a slight pain, which however soon passes off. If he is willing to remain at rest, the point may be kept in for fifteen, twenty, perhaps thirty-six days or more, without inducing either inflammation or suppuration, or even redness; and if it does not slip from being inserted too obliquely into the inner face of the bone, the little wound left when the instrument is removed will heal up in about twenty-four hours. I first published two successful cases; M. Davasse has since given several others;* and the apparatus has always proved as harmless as it is efficient. In the majority of cases there remains not the slightest prominence on the surface of the bone. In one instance reported by M. Davasse, the point had induced the deposit of a little bony tubercle, hardly sensible to the touch, and completely painless, but which had not disappeared after the lapse of eighteen months.

[Dr. Christopher Johnston, of Baltimore, tells me that in 1852 he saw this contrivance used with perfect success in two cases, under the care of M. Malgaigne himself.]

I have said that the point may slip in consequence of the intracta-

* Malgaigne, *Nouvelle méthode de traitem. pour les fract. très-obliques de la jambe, Journal de Chir.*, September, 1843; Davasse, *Obs. sur l'emploi de l'appareil à vis dans le traitem. des fract. obliq. de la jambe, Archiv. Gén. de Médecine*, July, 1846.

bility of the patient; this is because there is in fact no penetration of the bone, however great the pressure applied. In slipping, the point lacerates the integuments, producing a small wound which is sometimes ten or twelve days in healing; but even then there have never occurred any further symptoms. Sometimes at the end of five or six days the point begins to be unsteady, from the yielding of the pads and of the tissues; then the strap should be tightened, or the screw turned. Lastly, when the thread of the screw runs too wide the action of the muscles frequently suffices to turn it back, lessening the amount of pressure; this is to be prevented by tying the head of the screw.

Such is the method, a novel one to be sure, which I have used so often as to place its efficiency beyond a doubt. It maintains the fragments in close contact, so that they are not deranged by moving the foot upon the leg, and so that neither lateral splints nor permanent extension are necessary; we need only prevent the falling of the foot outward. Consolidation ensues as quickly in the most oblique fractures as in any others; so that whereas I devised the plan for cases in which perforation of the skin was threatened, I employ it at present in the majority of oblique fractures, merely to insure firm union.

It is especially in compound fractures that I have found this instrument invaluable; by insuring complete immobility of the fragments we allay the inflammation, and diminish the amount of suppuration; I have succeeded in obtaining consolidation in forty days, in splintered fractures communicating with the external air by lacerated wounds. In one case, indeed, there was a large splinter lying loose between the tibia and fibula; this remained movable, but consolidation ensued rapidly, without any suppuration taking place.

There are however some compound fractures which cannot be kept in place even by this means. The wound is so large, and the fragments are so stripped and loosened, that they both equally need retention. I have twice used two screws, one applied to the upper and the other to the lower fragment. In a still more troublesome case, even this did not suffice to keep up the coaptation; I tried passing around the broken ends a thread ligature, and afterwards one of wire, to hold them together,—almost a desperate attempt; and indeed most of my efforts of this kind failed; but I have succeeded at least once in preserving a limb which, but for the adoption of such extreme measures, would have been condemned to amputation.

I shall add but a few words, in relation to certain deformities resulting from such fractures of the leg as are totally neglected. In a case in which the fragments formed an acute angle opening backward, M. Josse, of Amiens, resected both bones, affording the patient a limb which, although shortened, was well-shaped and capable of fulfilling all its functions. I have myself had a similar operation

to perform in a nearly similar case; unfortunately the wound was attacked with hospital gangrene, and the patient perished; but the autopsy showed that there had been no burrowing or purulent deposits in the limb, so that apart from the accidental condition set up, a favorable result might have been looked for. [A very favorable case of this kind is related in a note on p. 274.]

§ II.—*Fractures of the Tibia.*

Fractures of the tibia alone are quite rare, compared with those of both bones; which rarity is accounted for when the causes producing them are inquired into.

These causes are direct or indirect. Thus, the patient being first overthrown, the leg may be crushed by the fall of some heavy body upon it, or by the passage of a carriage-wheel over it; and it is easily seen how unlikely it is that a pressure or a blow sufficiently forcible to break the tibia should be unable to overcome the slight resistance of the fibula. If on the other hand the patient is standing up, and the tibia receives the shock, the giving way of this bone throws the whole weight of the body upon the fibula, which is unequal to the support of such a load; the same occurs when the tibia is first fractured by a false step or a fall from a height upon the feet; the fibula rarely escapes unbroken.

There is however no surgeon who has not sometimes seen fracture of the tibia alone, or at least without any recognised injury of the fibula. Either extremity of the bone, or its shaft, may be affected.

These fractures may be serrated, oblique or comminuted. I have elsewhere said, and I would now repeat, that the fractures described by authors as *en rave* have never been observed.

The symptoms are severe local pain, increased by pressure or by any attempt at walking; swelling, and sometimes ecchymosis. Displacement rarely exists; the uninjured fibula serves not only as a lateral splint, but plays the part of an extending apparatus, opposing an almost invincible obstacle to overlapping. Thus patients with this form of fracture have been known to walk, in spite of the pain. Nevertheless, in consequence of the external violence, one of the fragments may be made to encroach upon the interosseous space, and the other to project inward, or inward and forward; to speak more accurately, in the majority of instances, it is the whole lower portion of the leg which is carried outward, or backward, or even forward, from the upper fragment; the mobility of the peroneo-tibial articulation above allowing this to occur without any other rupture taking place. This kind of displacement is easier, the nearer the fracture is to the knee-joint; thus Boyer saw a case in which the upper part of the tibia was broken by the kick of a horse, in which

the fragments were so displaced that they could not be adjusted, and the bone remained warped forward. In the Musée Dupuytren (No. 212) is a fracture at the upper third of the tibia, the fragments in which are carried backward and outward so as to form an angle of 160°, and to narrow considerably the interosseous space.

Sometimes also there occurs partial separation of the two bones at their lower extremities, favoring this displacement; lastly, in young subjects, the fibula may bend without breaking, or as the result of incomplete fracture; I have more than once caused such curvatures of the fibula in animals, after having broken the tibia; and I have elsewhere cited M. Campaignac's remarkable case of a girl twelve years old, whose tibia had been fractured at its middle by the wheel of a cabriolet. The lower fragment projected forward and inward; the leg could not be completely restored to its natural form, and the callus was deposited with a slight angle in the direction mentioned. The patient dying some time after, dissection revealed an incomplete fracture and a curvature of the fibula.*

Finally, fracture sometimes affects the tibia above its upper articulation with the fibula, and then of course the latter bone can present no obstacle to displacement. *Fig.* 86 would afford an example of this, were not the fibula also broken. Sometimes, as in this figure, the line of fracture runs downward and forward; or it may be oblique from one side to the other, as in the partial fracture represented by M. Campaignac. I have seen a case in which this portion of the tibia seemed to be crushed; the upper fragment has been seen divided into two parts; lastly, what forms a more important difference, the knee-joint may or may not be concerned; the joint however is generally entered, when there ensues effusion as considerable as in fractures of the patella or of the femoral condyles. As to other phenomena, there may be no appreciable displacement, doubtless owing to the serrations and the periosteum keeping the fragments in contact; but we more commonly find the upper fragment tilted up by the quadriceps, acting upon it without any opposition; and the prominence which it makes in front is the more pronounced in proportion as the knee is more flexed.

On the whole, these displacements rarely go so far as to give rise to any serious deformity; often, on the contrary, the perfect contact of the fragments prevents crepitation, and our diagnosis can be only a probable one. We may, however, infer the existence of fracture when the patient, after sustaining a fall or a blow, experiences at one portion of the tibia a sharp and circumscribed pain, persistent, increased by pressure or by any attempt at walking, attended with some engorgement; and especially when his sleep is disturbed by startings of the limb. If in running the finger along the spine of the

* *Journal Hebdomadaire,* tome iv, p. 100.

tibia we perceive any inequality; if by pressing the fragments in opposite directions we can detect mobility or crepitation, our diagnosis is rendered almost certain.

I do not say that it is quite certain, because it remains to be decided whether the fracture is limited to the tibia, or involves the fibula also. Now, not only is this differential diagnosis not always easy, but as was said in connection with fractures of the leg, slightly marked as the fracture of the fibula may be, and careful as our investigations must be to detect it, prudence should forbid our going too far, making us willing rather to remain in ignorance of a complication which can have no influence on our remedial measures.

The treatment is very simple; when there is no displacement, or when the displacement, being reduced, does not tend to recur, it is sufficient in many cases to keep the limb lying on a cushion for thirty-five or forty days, which is about the time required for consolidation. It is always safer however, in order to avoid any risk of displacement, to support the leg either by lateral splints, by an immovable apparatus, or upon a double inclined plane. I prefer using the double inclined plane or the lateral splints for the first few days, until there is no longer any fear of inflammation; but after that, the dextrinated bandage has the recommendation of enabling the patient to go about on crutches.

The only inconvenience to be apprehended is troublesome stiffening of the articulations. This is to be obviated by slight flexion, if the patient is compelled to observe perfect rest; by careful movements at the knee and ankle, when there is no contra-indication.

Fractures at the upper end of the bone generally entering the joint, absolute rest is essential; the thigh must then be confined as well as the leg, and it is then particularly that the knee is apt to become rigid. Slight flexion of the leg upon the thigh is therefore preferable unless the fragments have a tendency to become displaced.

But when the upper fragment is carried forward by the action of the quadriceps muscle, the least degree of flexion tends to increase the displacement, which diminishes or disappears when the leg is straightened out. Syme resorted to extension in one case of fracture at the upper end of the bone, communicating with the joint;* and I should not hesitate to employ it, for my own part, if the displacement were sufficiently remedied in that way. But in cases requiring more efficient means, I should much prefer putting the limb in a slightly flexed posture on the double inclined plane, and correcting the projection of the fragment by applying the screw described in the foregoing section.

Sir A. Cooper has thrown out some ideas, in regard to fractures of the upper extremity of the tibia, which may perhaps be somewhat

* *Archiv. Gén. de Médecine*, 1836, tome xi, p. 97.

unsafe. When the joint is involved, he advises extension of the leg on the thigh, in order that the femoral condyles may act as a horizontal splint upon the articular face of the tibia, and keep it in exact position; moreover he advises approximating the fragments anteroposteriorly by means of a pasteboard splint and a roller. This splint and bandage would seem to fulfil the same indication as my screw apparatus, but with less certainty, and with the danger of continuous pressure upon the skin covering the bone. As to the efficiency of the condyles of the femur by way of a splint, it needs only to be remarked that they do not press much more against the tibia in complete extension than in slight flexion of the knee.

But if the fracture, although oblique, does not penetrate the joint, Sir Astley recommends the double inclined plane, provided, says he, that the deformity is the result of the riding up of the lower portion, and that it is obviated by the weight of the leg upon the plane. The best proof that the upper fragment may be displaced by itself, without any overlapping of it by the other, is that it has been seen projecting anteriorly even in fractures at the middle of the bone, when the resistance of the fibula prevented the occurrence of any overlapping whatever. Sir Astley Cooper was therefore misled by an idea more plausible than correct, and moreover unsupported by any observations.

§ III.—*Fractures of the Fibula.*

In our *resumé* of cases at the Hôtel-Dieu, of 515 fractures affecting the bones of the leg, only 109 involved the fibula by itself. This proportion is evidently too small; since during the interval from 1806 to 1808 they were frequently confounded with simple sprains. In fact, within that time only twelve of them were detected among 150 fractures of the leg, making them amount to less than one-twelfth. Dupuytren would have it, on the contrary, that they were to all other fractures of the leg in the ratio of one to three, which seems to me to be the opposite extreme. From 1830 to 1837, the registers of the Hôtel-Dieu record 97 fractures of the fibula to 365 of the leg, or a little more than one-fourth. This is nearly the same proportion as that found by Lonsdale himself at the Middlesex Hospital, 51 to 197, and is the one which seems to come closest to the truth.

In examining our 109 cases in reference to the influences of age and sex, we arrive at some quite curious results. In the first place there is not one below the age of fifteen, and from fifteen to twenty-five they are still quite rare, there being only thirteen. From twenty-five to fifty we find seventy-one, almost two-thirds of the whole number; the fracture in question is therefore one in great measure peculiar to adult age. Between fifty and seventy years there are

twenty, and only five between seventy and eighty; above this there are none at all.

Since it belongs to adult age, this fracture ought to occur much more commonly in men; the general proportion is eighty-eight to twenty-one,—more than quadruple; but this varies remarkably according to age. Thus we find

From 15 to 25 years	- - - -	8 males,	5 females.	
" 25 to 50 "	- - - - - -	64 "	7 "	
" 50 to 70 "	- - - - -	14 "	6 "	
" 70 to 80 "	- - - - - -	2 "	3 "	

It would seem more frequent in winter than in summer; the last three-quarters of the year do not present any great difference in this respect, giving in all sixty-seven cases; but the first quarter by itself has forty-two.

Lastly, Dupuytren, having collected 207 cases, says that seven-tenths, or more than two-thirds of them, involved the right leg.*

The fibula is rarely broken by direct causes, such as the passage of a carriage-wheel, the shock of a heavy body falling or violently propelled, etc. Indirect causes much more commonly give rise to it, and have therefore attracted much more attention among surgeons.

David, in 1771, under the name of *Bazille*, spoke of a fracture produced by *falling obliquely upon the feet*, but gave no further explanation. Pouteau, believing that he had detected this fracture after missteps which had not even been followed by the patient's falling down, thought they might be occasioned *by the mere commotion from violent contraction of the peronei muscles.*† Boyer was the first to assert that the fibula is broken in two quite different ways, by violent adduction or abduction of the foot. In the first, says he, the astragalus pushes outward the lower extremity of the fibula; in the second the latter bone is acted on from below upward by the calcaneum. This view, although purely hypothetical, seemed plausible, and was quite generally adopted.

Dupuytren himself, although affecting to ignore Boyer's statement, borrowed from him the basis of his doctrine, acknowledging precisely the same causes as efficient. His explanation was somewhat different; in adduction he admitted the pressure of the astragalus from within outward against the external malleolus, but added the traction exerted upon that process by the lateral ligaments, this latter being in his opinion the essential agent in producing the fracture. In abduction, he denied that any pressure was made by the cal-

* Dupuytren. *Mém. sur la fract. de l'extrémité inf. du péroné*, etc., *Annuaire des Hôpitaux*. Paris, 1819.

† Bazille. *Mém. sur les contre-coups*, etc., *Prix de l'Academie Royale de Chirurgie*, tome iv, p. 572; Pouteau, *Mém. sur les fract. du péroné*, *Œuvres Posthumes*, tome ii, p. 267.

caneum; according to him the first effect of forcible abduction is to break either the internal lateral ligament or the inner malleolus; and the fracture of the fibula, always consecutive, is then "caused by the change made in the line of transmission of the weight of the body, which in place of coinciding with the axis of the limb and falling upon the astragalus, abandons that axis, and strikes at some point about the lower extremity of the fibula." This theory was defended both by observations and experiments. Thus of 207 fractures of the fibula, setting aside one-tenth as due to direct violence, the remainder were divided as follows:

·6, were produced by forcible adduction of the foot;
·3, " " " abduction " "

His experiments were these. The foot of a dead subject being fixed in a vice, so as to leave the tibio-tarsal articulation free, by carrying the upper part of the leg forcibly inward, which was the same as making strong adduction of the foot, fracture of the external malleolus without displacement was the constant result; by carrying the upper part of the leg outward, or making abduction, fracture of the inner malleolus was first produced, and subsequently the fibula gave way at its lower extremity. Finally, if instead of fixing the foot in a vice, *points d'appui* were taken upon one of its edges, adduction always caused fracture of the fibula at a higher point than in the preceding experiments.

M. Maisonneuve has repeated these researches, but not with entirely similar results.* Thus he has always seen the internal lateral ligament ruptured by forcible abduction, without any fracture either of the internal malleolus or of the fibula; he therefore rejects the idea of fracture by abduction. By adduction, on the contrary, he has easily succeeded in fracturing the external malleolus, but always transversely, and on a level with the lower end of the tibia. He admits therefore a fracture by adduction, produced by traction on the ligaments, as pointed out by Dupuytren, but essentially limited to the outer malleolus; and he gives it the name of fracture *par arrachement*, [by tearing off.]

But it is not, according to him, in this way that most fractures of the fibula take place; it is chiefly by a rotation of the foot, by which its point is carried outward, "when for instance, the foot being caught between two stones in a pavement, the body moves forward and inward; or perhaps when, twisting upon its inner border, the foot is deviated outward and backward, while the leg is either fixed by the weight of the body, or turned in the contrary direction." In such a movement, the foot represents an inflexible stem jointed at a right angle with the mortise formed by the tibia and fibula, and pressing

* Maisonneuve, *Recherches sur la fract. du péroné, Archiv. Gén. de Médecine*, Feb. and April, 1840.

the external malleolus from within outward and from before backward. If we imagine a fixed mortise into which a lever is introduced perpendicularly, and a force applied to the upper end of this lever so as to incline it, one of the sides of the mortise must inevitably be broken; and this is what takes place in the foot. Now why should the outer malleolus be broken rather than the inner? On account mainly of the arrangement of the lever. Suppose the foot to be five inches in length from the point of the toe to the posterior border of the astragalus, and the portion of this bone engaged between the two malleoli to be one inch in length; when the point of the foot is carried outward, the foot itself acts upon the tibia as a lever of the first order, taking its fulcrum on the anterior edge of the fibula; the resisting arm will have a length of one inch, and the other a length of only four inches. But upon the fibula the foot acts as a lever of the second order, taking its fulcrum on the posterior edge of the inner malleolus. The resisting arm will still have its length of one inch, but that of the other arm will be five inches; whence it is evident that the lever must act much more powerfully upon the outer malleolus than upon the inner. M. Maisonneuve calls the resulting fracture a fracture by *divulsion*.

It sometimes, however, happens that the malleolus resists, and that the whole of the force is spent upon the ligaments connecting the foot with the tibia. These ligaments being ruptured, the fibula is separated from the tibia as well as carried backward; and if the muscles, the interosseous ligament, and, above all, the attachments of the upper articulation oppose too great a resistance to this double movement, it is the fibula itself which yields, as if by a kind of torsion; the fracture is always situated higher up than the two preceding forms are, generally involving the superior third of the bone; and since it is always preceded by separation of the two bones, M. Maisonneuve calls it a fracture by *diastasis*.

Such are the theories which have hitherto prevailed in reference to indirect fractures of the fibula. Now in order to judge of their incorrectness, we need only say that experimenters, by forcible adduction of the foot or of the leg, have never been able to procure any fractures but those of the outer malleolus, and that their "fracture by *arrachement*" has nothing to do with fractures of the fibula, properly so called. A more curious fact in regard to "fracture by *diastasis*" is, that it has not yet been observed in the living subject, and that the unique example of it reported by M. Maisonneuve turns out to be a fracture of both bones.

Let us now leave these problematical lesions, and return to actual facts. Now it is constantly seen by practitioners that indirect fractures of the fibula, as occurring in the living subject, are generally seated about two inches above the tip of the malleolus,—rarely either higher up or lower down. According to the statements of our patients,

the injury is for the most part produced by forcible adduction of the foot; that is to say, as the effect of a fall or a misstep, bringing the weight of the body upon the outer edge of the foot. It seems to me very difficult to determine the precise mechanism; I would only remark that this adduction of the foot is ordinarily accompanied by an inclination inward of its point. This is all we can obtain from observation; and in order to avoid hypothesis, I shall name these fractures, from their cause, fractures by *adduction*.

Others are ascribed by the patients to a fall or a misstep, by which the weight of the body is thrown on the inner edge of the foot, which is therefore abducted. M. Maisonneuve rejects this evidence, and would make out that the fracture is due to rotation outward of the point of the foot. Now if the reader will try for a moment to walk on the inner edge of the foot, he will be convinced that by this movement the point of the foot is almost unavoidably directed outward; so that the fracture then takes place at once in the manner described by the patients and according to the mechanism so clearly pointed out by M. Maisonneuve. It is in my opinion only in very rare and quite exceptional cases that rotation of the point of the foot acts by itself, without abduction of the whole foot; and for this reason I should prefer the name of fracture by *abduction* to that of fracture by *divulsion;* the latter having but a limited application, while the former is derived from the most general cause.

Such, then, are the two great divisions of indirect fractures,—those by adduction and those by abduction. Not that I would assert that no other varieties exist; M. Rognetta, for example, has produced them in the dead body by making forcible extension of the foot;* and if we consider the diversity of circumstances under which fractures of the fibula occur, by the foot striking a stone, or meeting with a hollow or an inequality in the ground, by its slipping away from the other, or being caught between two of the stones of a pavement, resting on its point or its heel, on its inner or outer edge, its point inverted or everted, the leg flexed or extended; if we add to this the different attitudes, and especially the weight of the body, which is an element wanting in all experiments on the dead subject, we must perceive that the most comprehensive theory would hardly embrace such manifold conditions. Moreover, this would be of little practical value, since it is very rarely that the patient can give an accurate account of the way in which his accident happened.

May we not, however, refer to the two grand causes indicated some special forms of fracture, so that, the fracture being recognised, we may trace it to the cause producing it? There is one at least in which this retrospective diagnosis would seem extremely probable; it is the one which M. Maisonneuve has particularly studied.

* *Archiv. Gén. de Médecine*, 1833, tome iii, p. 499.

A woman, thirty-five years old, having made a misstep in descending a staircase, sustained a fracture of the fibula, and at the same time one of the skull, and died a few hours afterwards. The former of these injuries is represented in *Fig.* 94. The line of division runs downward and forward, and a little inward, beginning at the posterior edge of the bone five centimètres above the point of the malleolus, and ending in front two centimètres above it, vertically, just on a level with the articular face of the tibia. The upper fragment remained adherent to the tibia; the lower one was separated from it and thrown outward and backward, so that, while still in contact with the other by its posterior edge, the two were apart anteriorly by two or three centimètres, leaving between them a triangular space; the apex of this space being upward and backward, and its base downward and forward. This separation was greatly increased by carrying the toes outward, but disappeared when they were turned inward. Neither abduction nor adduction had any effect on these phenomena, so that it might justly be inferred that eversion of the point of the foot was the main agent in both the fracture and the displacement.

I have met with several cases of this kind in the living body; and the account of the patients has more than once corroborated the inference drawn from the form of the fracture. But we are not so well informed in regard to other varieties.

Fig. 95 represents a recent fracture at the lower extremity of the fibula; it is oblique from above downward and from without inward, commencing two inches above the point of the malleolus, and running down to just about the middle of the peroneo-tibial junction. *Fig.* 96 is an exactly similar case, except that there is a pretty marked separation of the lower fragment outward. On the other hand, M. Pigné has deposited in the Musée Dupuytren a remarkable specimen, (No. 232,) in which may be seen, besides a tearing off of the tibial malleolus, a fracture running very obliquely downward and backward, in such a way that, beginning on the anterior surface of the fibula, nearly four inches above the malleolus, it terminates posteriorly about two inches above it. The lower fragment is carried a little in front of the upper.

The first question which arises is, To what variety do these fractures belong? I presume, but cannot assert, that they are the result of adduction. Can it be deduced from this that fractures by adduction are characterised by obliquity downward and inward, or downward and backward, while those of the other form have their special obliquity downward and forward? This would be a very bold assumption; and Dupuytren's seventeenth observation clearly shows a fracture by adduction, transverse, and seated an inch and a half from the malleolus. On the other hand, his twenty-sixth and twenty-seventh observations have reference to very oblique fractures, which were due to direct violence. Still, it may be stated as a general rule

that indirect fractures present a certain obliquity, while the direct are usually transverse.

Fig. 97 shows a direct fracture seated, like the preceding, about two inches above the malleolus; it is nearly transverse.

Direct fractures may affect any portion of the bone, and present no peculiar phenomena. It is but rarely that mobility and crepitation are perceived; inequalities resulting from any displacement are quite as uncommon, and we must generally be content with a probable diagnosis, derived from the cause, the fixed and persistent pain at the point of injury, and the accompanying ecchymosis.

Sometimes, however, the lower fragment of the fibula is driven in toward the tibia so forcibly as to produce deviation outward of the malleolus, and consequent deformity of the foot. Fabre reports a fracture resulting from the passage of a carriage-wheel over the lower extremity of the leg. The swelling was considerable, but the foot retained its normal position; it was only after the subsidence of the swelling that the foot was seen to be thrown outward, and the patient was permanently lamed. Dupuytren has published a still more remarkable case, in which the displacement seemed to have been the effect of the fracture itself.* The same author says also that he has seen in two or three patients, and in a much greater number of dead bodies, one of the fragments projecting outward and the other driven in; but the information given concerning these cases would seem to indicate that the displacement was due much less to the fracturing cause or to muscular violence than to the application of a very tight circular bandage. I have for my own part never met with anything of the kind.

As to fractures by adduction, the first point which it is important to establish, contrary to the usual views of authors, is that in the majority of cases there is no displacement whatever; that the injury is recognised, like a direct fracture, only by the pain and ecchymosis. It is not uncommon to see patients walking in spite of this fracture; and I saw one man who was able to go a league on foot, to his home, without at all disturbing the exact contact of the fragments. Dupuytren has indeed reported two analogous cases, *i.e.*, without any displacement; but being preoccupied with the idea of bringing his apparatus into use, he saw in them only exceptions; and in his statistical summaries he asserts that nine-tenths of his fractures were attended with displacements. There remains, therefore, but one-tenth without displacements, and when it is remembered that he estimated one-tenth of his fractures to be direct, it may be seen that his idea was that displacement almost necessarily accompanied every indirect fracture. Now I do not hesitate to declare that in regard to

* Fabre, *Recherches sur diff. pointes de physiologie*, etc., 1783, tome i, p. 299; Dupuytren, *op. cit.*, obs. 27.

this, Dupuytren has led other surgeons into error; and that his results are irreconcilable either with my own personal experience, or with what I have seen in his wards at the Hôtel-Dieu. I repeat, in order that no doubt may remain; in most cases of fracture produced by adduction of the foot, there is neither displacement, swelling, nor deviation of the foot; it gives the patients pain to walk, and they put the foot to the ground only very cautiously; some instinctively try to rest on its outer edge; but these signs are common to sprains as well as fractures. Ecchymosis is in my opinion an almost characteristic symptom; for I do not think I have ever observed it in a mere sprain. But an easy and certain means of diagnosis between the two lesions consists in pressing with the thumb over the lateral ligaments, and then over the outer surface of the fibula at three, five or seven centimètres from the point of its malleolus; pain on pressure upon the ligaments indicates a sprain; pain at some one point in the bone belongs almost exclusively to fracture.

Why then is it that in Dupuytren's observations fractures by adduction would appear to be so often complicated with displacement, and consequently with luxation of the foot? The facts answer for themselves; it is because all patients, having had the fibula broken by forcible adduction, still attempt to walk; and then the foot is turned outward into abduction, giving rise to displacement and all its consequent symptoms. This secondary displacement occurs sometimes even in direct fracture, when the patient rests on the outer edge of his foot; Dupuytren has given several such instances.

But is fracture by adduction never attended with any displacement of any kind? Although I have not seen it myself, I would not deny its possibility. Dupuytren's ninth observation is the case of a woman fifty years old, who in going down a staircase made a misstep, bringing the weight of her body upon the left foot, which was put out forward and somewhat inward; the left leg bent on the thigh, and slid with the body along down the staircase, bearing upon its outer side. An extensive abrasion was presented on the external surface of the foot and leg; the fibula, broken two inches above the tip of its malleolus, was movable, and could be pushed toward the tibia with a perceptible crepitus. There was no visible displacement, prominence of the malleolus, depression above it, deviation, nor rotation of the foot in any direction; nevertheless, by fixing the leg with one hand, and with the other carrying the foot alternately inward and outward, the latter could be made to move transversely over a space of at least an inch; and then only there appeared some symptoms of luxation outward of the foot.

Such is Dupuytren's account; and now the question is whether or not the fracture was actually produced by adduction. I have seen several cases presenting exactly similar phenomena; in one I could not determine the precise cause of the lesion, but in all the rest there

had been abduction, with the toes turned outward. This is a point which needs to be elucidated by further observation.

It is evident, from what has been said, that fracture by abduction may itself occur without any appreciable displacement; of this M. Maisonneuve gives two examples. In these cases, as in the preceding varieties, the patient walks with great difficulty; there is ecchymosis, swelling, and local pain on pressure above the malleolus; but moreover, by fixing the leg firmly and abducting the point of the foot, the malleoli are manifestly separated, often even with marked crepitation.

When this separation is persistent, which is ordinarily the case, it involves other phenomena which it is important to consider. The foot is placed in abduction, especially marked at the toes; sometimes its point alone is carried outward, the heel maintaining its ordinary direction. The inner malleolus projects beneath the skin, particularly by its anterior edge. The separation outward of the outer malleolus leaves above it a depression, or entering angle, to which Dupuytren gave the singular and not very intelligible name of *coup de hache*, [axe-stroke.] Tracing the anterior edge of the fibula, we come to the sharp prominence of the end of the upper fragment; sometimes I have found this movable, so as to sink in under pressure, starting up again when left to itself. Finally, between this point and the malleolus, we detect the notch separating the two fragments, widening upon eversion of the point of the foot, and narrowing by its inversion.

When the displacement is slight, although the articular surfaces have actually undergone some derangement, it may be taken for granted that the whole is to be ascribed to the fracture; but the displacement cannot be carried very far unless there is a rupture either of the internal lateral ligament, or of the inner malleolus itself, and consequently a true luxation of the foot. In the specimen represented in *Fig.* 94, there was at the same time a complete detachment of the anterior annular ligament of the ankle-joint at its tibial insertion, and rupture of the anterior and middle fasciculi of the internal lateral ligament. When the luxation takes place, all these phenomena are much more marked, and sometimes the foot is so much abducted that its outer edge looks almost directly upward; but this is not the proper place for discussing this lesion, which is much more serious than the mere fracture, and which strictly belongs under the head of luxations.

The diagnosis, when there is no displacement, may waver between a fracture and a mere sprain; I have already mentioned the mode in which it can be rendered at least probable. I must insist here upon the necessity of care in forming the diagnosis; I have more than once seen these fractures undetected because no crepitation or displacement was present; the least that can happen in such a case

is the persistence of pain until proper treatment is instituted, and in some unfortunate instances injudicious attempts at walking have given rise to luxation of the foot. When there is displacement, it is only necessary to examine whether or not it is attended with rupture of the internal lateral ligament or of the inner malleolus.

The prognosis, when there is no displacement, is very favorable; and a slight degree of displacement, without any other complication, will yield quite readily to proper treatment. When Dupuytren described fracture of the fibula as so grave a lesion, it was because he thought fit to associate with it every species of tibio-tarsal dislocation, which should assuredly have been discussed separately.

The treatment of these fractures without displacement is the simplest thing in the world; we may almost be content with keeping the limb at rest, and waiting for consolidation. It is however safer to guard against any sudden movement of the foot; if therefore there is any swelling, I place the leg and foot between two lateral cushions, supported by two side-splints, admitting of the application of cataplasms if necessary; the swelling having subsided, the foot and lower half of the leg should be enveloped in a starched or dextrinated bandage, and the patient may be allowed to go about on crutches.

When displacement exists, the first point is to restore the foot to its proper direction, and to put the outer malleolus in contact with the tibia. This is generally easy; if necessary, reduction may be favored by flexing the leg, so as to relax all the muscles; and I doubt whether, except in cases of luxation, the surgeon need ever resort to the section of the tendo-Achillis, in imitation of M. A. Bérard.* But to keep the fragments in place is rather more difficult, and sometimes, either because the serrations do not properly interlock, or because there is some minute splinter between them, it is impossible to entirely overcome the widening of the intermalleolar space.

Various forms of apparatus have been devised for maintaining the broken ends in contact.

Boyer used two lateral splints, the outer one reaching a little beyond the foot, while the inner one came down only to the level of the internal malleolus.

Sir Charles Bell applied along the outer side of the leg and foot an angular splint, properly padded, and laid the leg on its outer surface, in a state of semiflexion. Sir A. Cooper employed two such curved splints, one on each side, and advised keeping the great toe on a line with the patella.

Dupuytren states the indications otherwise; he recommends "carrying the foot inward, the tibia being pushed outward, the lower fragment of the fibula raised, separated from the tibia, and in the

* See my *Journal de Chirurgie*, 1843, p. 341.

same direction with the upper portion of the bone." His apparatus consisted of a pad about twenty-seven inches long by three or four in width and about three in thickness; a firm splint, seventeen inches long by two or three wide; and two bandages five or six yards long. The pad, bent upon itself so as to form a wedge, was applied on the inside of the limb, its base below, bearing upon the internal malleolus but not reaching beyond it, its edge above, over the internal tuberosity; over this pad was placed the splint, which should reach about three inches beyond the inner edge of the foot; and both splint and pad were fastened to the limb with the first bandage. The free portion of the splint, thus separated by a considerable interval from the foot, served as a *point d'appui* for drawing the foot inward; and with this view the second bandage, having been first fixed by turns around the splint, was carried alternately over the instep and heel, embracing the splint and each of these parts in turns of greater or less firmness, which formed a figure-of-8 by crossing one another over the splint. As to the rest, Dupuytren, like Sir Charles Bell and Sir Astley Cooper, laid the leg on its outer surface, in the semi-flexed position.

M. Maisonneuve has remarked that this apparatus, drawing inward upon the point of the foot more powerfully than upon the heel, would answer the purpose completely in fractures by abduction, if it were not liable to become relaxed. He therefore employs it merely as a means of support for the dextrinated bandage. The reduction being made, and the foot somewhat forcibly adducted, he envelopes the foot and leg in a roller five or six yards long, soaked with dextrine, putting a good many turns about the seat of the fracture. Over this he applies Dupuytren's apparatus, to keep the foot in proper position until the dextrinated bandage is dried; after which the latter is sufficient, and the other may be left off as useless.

Now in order to judge between these different forms of apparatus, it is necessary to define precisely the indications. When reduction is made, we have simply to keep the fragments pressed together, so that they cannot slip. Boyer's splints exert indeed some pressure over the outer malleolus, but do not give sufficient support to the inner. That of Sir Charles Bell has the same defect; that of Sir Astley Cooper presses perhaps too uniformly over the whole outer face of the leg, to overcome a separation at all obstinate of the lower fragment; still, it must not be forgotten that the author obtained complete success with it in his own person. Dupuytren's splint tends to tilt outward the upper end of the lower fragment; it would be suitable at most only in fractures by abduction, as was remarked by M. Maisonneuve; and would certainly do great harm in such fractures as are shown in *Figs.* 95 and 96. Lastly, M. Maisonneuve's dextrinated bandage affords all the advantages of Dupuytren's splint, with greater solidity; although until it has dried, it is affected by the

unavoidable relaxation of the latter, and the forced adduction of the foot is, to say the least, useless.

There are some fractures in which the displacement is so slight as to be easily reduced, and as to remain thus, so to speak, of its own accord; here the simplest apparatus will suffice. Nevertheless, in order to make the double pressure on the fragments with greater firmness, I apply along the inner surface of the limb a pad, folded like that of Dupuytren; on the other side, another pad, whose greatest thickness is over the astragalus and external malleolus; supporting the whole by two lateral splints reaching below the sole of the foot. This apparatus might also be used to keep a dextrinated bandage firm until it became dry.

But I have met with cases in which the displacement was so obstinate as to reappear instantly on the cessation of pressure with the fingers upon the fragments; this pressure, to be efficient, needing to be quite firm. I have tried the flexed position, the two splints, Dupuytren's apparatus, the dextrinated bandage; nothing answered the purpose. I have finally employed plaster, running a mould around the limb; it constitutes in these cases an invaluable resource. The rules for its application have already been sufficiently set forth; there only remain certain precautions to be specially noticed here. The limb should rest on its posterior surface, the knee moderately flexed, the foot raised at a right angle and perfectly vertical. Reduction, being made, is kept up by the thumb of an assistant firmly applied over the outer malleolus, another assistant pressing in the opposite direction over the inner one. The plaster is now to be run, the assistants maintaining their pressure until its solidification is complete. The openings thus left may be filled up with the surplus plaster, or may be left unstopped without any inconvenience resulting.

Fractures of the fibula, without displacement, unite perfectly in about thirty days. When the displacement is such as to endanger the solidity of the tibio-tarsal articulation, it will be prudent to keep the apparatus in place for thirty-five or forty days.

§ IV.—*Fractures just above the Malleoli.*

I apply this name to a fracture hardly alluded to in the books, which is located about an inch above the tibio-tarsal articulation, and which may or may not run into the joint. Sometimes it consists of a nearly transverse division of both bones; M. Ph. Boyer met with one immediately above the articulating surface of the tibia; it is stated that there was no more bone between it and the articular cartilage than was absolutely essential to preserve the joint intact.*

* Additions to the fifth edition of Boyer's *Traité des Maladies Chirurgicales*, etc.

At other times the fracture is more irregular, with wide serrations; the lower fragment of the tibia may itself be broken into several pieces, and as it were crushed; *Figs.* 91 and 92 present a very fine example of this. In some cases it is the fibula, the inner malleolus, and the anterior or posterior half of the tibia which are divided; I have published an account of a fracture obliquely separating the posterior half of the tibia, and involving also both malleoli;* this will be again referred to in connection with luxations of the foot. *Fig.* 93 represents one of the other variety, that is to say, a triple fracture of the fibula, of the inner malleolus and of the anterior half of the tibia. Lastly, the tibia may be broken obliquely through its entire thickness, the fibula giving way at a point much higher up. It is evident therefore that these fractures assume various forms.

Their causes also differ greatly. I have seen a case produced by the passage of a heavily loaded wagon over the lower part of the leg. According to M. Ph. Boyer, the most common cause is a fall on the ground, the injured leg coming under the other, and thus sustaining the whole weight of the body. For my own part, it is mainly by falls from a great height, as from a second or third story, that I have seen these fractures to occur; the person alighting on the foot turned to one side or the other, or perhaps directly upon the heel; in *Fig.* 93, the posterior portion of the calcaneum is seen to be broken, leaving no doubt as to the fall having been sustained in this way.

Sometimes there is no displacement, or if there is any it is in the thickness of the bone, and is corrected without much difficulty. M. Ph. Boyer made a perfect cure of a fracture with considerable transverse displacement, in an old man of seventy, in the space of forty days. The treatment is here extremely simple; two lateral splints are sufficient, and after the subsidence of the swelling, which is always quite marked, the dextrinated bandage may be employed with perfect safety.

But there are other and much more troublesome displacements, in which the lower fragment forms an angle with the upper, so that all the phenomena of a tibio-tarsal dislocation are presented. Thus in the case represented in *Fig.* 91, the foot was turned inward, as in luxation inward; the fibula, broken nearly at the same level as the tibia, distended the integuments by the angle between its fragments. I have seen one case in which the foot was turned outward, the fibula torn from the tibia below, and the fracture far above, just below its head. Lastly, the before-mentioned separation of the posterior portion of the tibia was attended with luxation of the foot outward and backward.

The diagnosis is sometimes in such cases quite difficult, at least as regards the direction of the fracture, and all the accompanying appearances. When the foot is strongly twisted inward or outward, we

* *Gazette Médicale*, 1832, p. 647.

may be led to suspect luxation, especially if the parts are masked by the swelling; if otherwise, we can generally obviate any mistake by examination and measurement.

The prognosis is really serious, and more so by reason of the injury to the articulation, and the difficulties in the way of reduction. Stiffening of the joint is always to be dreaded; and sometimes the limb can only be saved at the expense of disagreeable deformity. If the lesion is complicated by a wound laying open the joint, the danger is essentially increased; and if at the same time the lower fragment is crushed, immediate amputation is almost the sole course available to us.

One or two cases will perhaps give a still more correct idea of the gravity of this fracture.

A woman forty-eight years old, in descending a staircase, twisted her foot outward, and fell; the whole weight of her body coming upon the leg, which was resting by its inner face on the ground. Hence there ensued a fracture just above the malleoli, the foot being carried outward and backward. Reduction was performed, and splints applied. Next day there was swelling, with phlyctenæ; the displacement was renewed, and Dupuytren employed his apparatus for fracture of the fibula, laying the leg, semiflexed, on its outer side. During the next few days the displacement tended to recur, and sloughs formed opposite the fracture; on the thirteenth day the state of the soft parts necessitated the removal of the apparatus; on the sixteenth it had to be reapplied, on account of the renewed displacement; abscesses began to appear; to be brief, the patient came out from all this, after one hundred and eighty days of treatment, with a considerable stiffening of the ankle, deviation of the foot outward and backward, and projection forward of the upper fragment of the tibia.

A young soldier had his leg caught in a land-slide, and broken close to the malleoli, the foot being so much twisted outward that its external edge looked upward. The ordinary apparatus for fracture of the leg was applied, but without avail; the displacement recurred; abscesses, sloughing, and exfoliation of bone supervened; eighteen months hardly sufficed for cicatrisation, and the patient could scarcely begin to use his leg at the end of two years, the foot being as much turned outward as on the first day, and the fragments forming a very marked angle inward.*

André Pasta has related the case of a man of forty-five, who sustained a compound fracture of the tibia near the ankle-joint. Reduction was made, but the next day it had to be abandoned on account of general convulsions. The symptoms were thus gradually dispersed; but the patient remained a cripple.†

Thus we see how serious such cases are, and how treatment will

* Dupuytren. *Mém. sur les fract. du péroné*, obs. 13 and 20.

† Léveillé, *Nouvelle doctr. Chirurgicale*, tome ii, p. 329.

sometimes fail even in the most skilful hands. It is above all important to aim at allaying muscular spasm by poultices, bleeding, opium or ether if necessary, and by relaxed position, flexing the knee to any required extent. As to apparatus, the inefficiency of splints and bandages is evident from the foregoing cases; and I know of none which under such circumstances would answer so well as my screw, before described.

[An excellent plan for the dressing of compound fractures, particularly those of the leg, was devised by Dr. J. R. Barton of Philadelphia; it consists in filling a fracture-box, such as was previously described, with bran; so as to form not only a bed but a covering for the limb. The extensive use of "Barton's bran dressing," throughout the United States, sufficiently attests its value.

In Geddings' *Baltimore Medical and Surgical Journal* for 1833, Dr. N. R. Smith published a description of a splint contrived by him, and intended for fractures either of the thigh or of the leg. This splint is now extensively known in the United States, under the name of its inventor; it is however more generally used for the leg than for the thigh. It is especially valuable in fractures seated very near the malleoli; by the kindness of my friend Dr. Addinell Hewson of this city, I have seen one such case in which no other apparatus could have answered the purpose so exactly. In the use of this splint, the principle of suspension is commonly adopted.

An account of this splint, to be complete, would occupy too much space to be inserted here, but the article itself is generally kept on hand by instrument makers.]

§ V.—*Fractures of the Malleoli.*

These fractures would seem to me to be extremely rare, at least in an uncombined form, I have observed barely three or four cases; and M. Ph. Boyer, who states that he has seen a larger number, has probably met with them by favor of fortune.

Sometimes they involve the outer malleolus, at the portion adjoining the articular surface of the tibia; sometimes the inner one, and sometimes both at once.

The outer malleolus is easily broken in the dead subject by violent adduction of the foot, and it was stated in the section on fractures of the fibula that neither Dupuytren nor M. Maisonneuve were able to obtain any others. The line of division is transverse, situated at or below the base of the process, or sometimes so low down that the injury is as it were merely a tearing off of the tip; the ensheathing fibrous tissues being unbroken, there is little or no displacement. Perhaps this want of displacement has sometimes caused these fractures to be mistaken for mere sprains; but the difference in the exact seat of the pain should serve to prevent such an error. If

there is any displacement, it is in the direction in which the foot is turned; and M. Ph. Boyer claims in fact to have seen cases of this kind in which the foot was twisted somewhat inward. The simplest apparatus will always answer here.

M. Nélaton has had an opportunity of observing a fracture of the external malleolus of an entirely different form; it was oblique downward, inward and forward, thus separating only the posterior and outer part of the process; it was attended with a dislocation of the astragalus, and was detected at the autopsy.*

Fracture of the internal malleolus is more common, and presents itself under two forms. In the first, the fracture is transverse, and nearly on a level with the articular surface of the tibia; sometimes it is close to the point of the malleolus, which seems to be as it were torn off. This variety quite frequently complicates bad fractures of the fibula, and is generally the result of forcible abduction of the foot by a fall or a misstep. The fragment is commonly retained in place by the fibrous tissues investing it, and almost our only clue to the lesion is the pain. But at other times it is completely detached, and drawn down by the internal lateral ligament; there is then a perceptible separation between it and the rest of the bone, increased by abduction, and diminished by adduction of the foot, and the broken piece can be grasped and moved to and fro. Sometimes the cause is a direct one, such as the passage of a carriage-wheel over the malleolus, and there is at first no displacement; but on the patient attempting to get up and walk, the foot, having lost its support on the inner side, is apt to be turned outward; hence there occurs a secondary displacement, or even a fracture of the fibula, also secondary; Dupuytren's twelfth observation affords an instance of this.

The second variety of this fracture is seated higher up, an inch or somewhat less from the hip of the malleolus; it separates this process from the rest of the bone by a division running obliquely downward and outward, and terminating almost invariably in the entering angle between the malleolus and the main articulating surface of the tibia. *Fig.* 91 represents a fracture of this kind complicating one just above the malleoli, and in *Fig.* 92 is shown the line of division of the articular surface. This injury would seem to be due generally to direct, but sometimes to indirect violence. I have recently seen an instance of its occurrence from the kick of a horse, in a little girl eight years old. Dr. Isaac Hays has seen a similar one in a man of sixty-five, who in an access of delirium jumped from a second-story window, alighting on a cellar-door fastened with a padlock; a small wound over the malleolus gave the idea that it had struck upon this padlock, the fracture resulting from the blow.†

In the last-mentioned case, although the fragment was but slightly

* *Bulletin de la Société Anatomique*, 1835, p. 38.

† *American Journal of the Med. Sciences*, Aug., 1837, p. 535.

movable, its limits were exactly defined to the touch; there was no tendency to inclination inward of the foot. In my little patient, on the contrary, the foot was somewhat turned inward; but there was no difficulty in making reduction, and by merely fixing the leg and foot between two lateral splints, a cure was effected without the slightest deformity.

Lastly, both malleoli may be broken at once. M. Ph. Boyer claims to have seen a good many such cases; according to him, they are always produced by forcible abduction or adduction of the foot, but more commonly the latter; and the false step made in slipping from a sidewalk is their most frequent cause. They may affect the malleoli at any point, from the base to the tip, sometimes with and sometimes without rupture of the periosteum; in the former case the foot will be twisted either inward or outward, according to the particular movement giving rise to the double fracture; but this displacement may be readily corrected. The malleoli seem further apart than in the sound limb; the solution of continuity may be recognised by the touch, and our author remarks particularly that the patient can raise the foot up without the assistance even of his own hands. Pasteboard splints and a roller, and afterwards a starched or dextrinated bandage, suffice to keep the fragments in position; at the end of forty or fifty days the patient is able to walk; but he should be directed to wear for some time a gaiter or a laced stocking. Sometimes there remains rather more difficulty in walking than after other fractures of the leg; in other cases there is no difference.

I have merely given M. Boyer's description, not having myself had an opportunity of seeing similar cases. I have indeed occasionally met with fracture of the inner malleolus together with one of the lower extremity of the fibula, as a consequence of falls, and Dupuytren obtained the same in his experiments with forcible abduction of the foot. Most commonly there is then luxation; but I have treated one patient, thirty-four years of age, in whom there was no displacement of any kind; the fracture of the fibula was however above the malleolus.

The swelling does not always permit us to ascertain the exact seat of the fracture, which after all is of no very great practical importance. The only case in which both malleoli have seemed to me to be broken, was that of a railroad employé; he had the point of his foot entangled under a rail, when his heel was struck by a cross-tie thrown with great violence. The foot, being caught between these two forces, was preternaturally extended upon the leg; there was a sprain of the anterior part of the ankle, and rupture of both malleoli, as far as could be made out for the swelling. There was no displacement; I simply applied two lateral splints, taking care to keep the foot and leg at a right angle; and the patient readily recovered, having at the time of his discharge only a quite marked swelling of the ankle, and some stiffness of the joint.

CHAPTER XIX.

FRACTURES OF THE FOOT.

These, like fractures of the hand, are much more frequently met with in men than in women; and they are mostly the result of direct violence, such as the fall of a heavy body, or powerful pressure of some kind. Falls on the feet here come under the head of direct causes, in regard to certain bones; thus I have several times seen most of the bones composing the tarsus broken by falls from a second or third story. This is indeed the most common cause of fracture of the tarsus; its slight projection securing it in great measure from the action of external forces. Ledran, however, reports a case in which it was crushed, without any displacement, in a coachman whose horse fell under him while galloping. M. Marjolin saw a still more curious case; it was that of a soldier, who, seeing a spent ball rolling along, tried to stop it by putting his foot upon it; such a ball, as is well known, retains for a long time a rotatory movement, and may even bound if touched; this did actually occur, and the tarsal bones were so crushed as to necessitate amputation.* In all cases in which nearly all the bones of the tarsus have been thus destroyed, either the patient has soon succumbed, or the removal of the foot has been requisite. I shall therefore delay no longer upon the subject.

The fractures which we have to consider particularly are: (1) those of the astragalus; (2) those of the calcaneum; (3) those of the metatarsal bones; (4) those of the phalanges of the toes.

§ I.—*Fractures of the Astragalus.*

These are always the result of falls from a height, the person alighting on the feet; but there is this remarkable circumstance concerning them: that in cases of general crushing of the tarsal bones I have almost always found the astragalus intact, while at other times it seems to sustain the full effect of the fall, being the only bone which is fractured.

* Ledran, *Observ. de Chirurgie*, tome ii, p. 352; Marjolin, *Cours de Pathologie Chirurgicale*, p. 365.

Nothing is more variable than the direction of this fracture. M. Tavignot met with one extending antero-posteriorly through the body of the bone, the neck of which presented also an incomplete transverse fracture.* I have in my collection a specimen of a very different form, the bone being divided almost transversely into two portions, one anterior and the other posterior. Lonsdale saw the astragalus split in two or three directions. Lastly, Rumsey communicated to Sir A. Cooper a still more singular variety, the bone being separated in a nearly horizontal direction, one fragment being superior and the other inferior.

In all these cases the existence of the lesion has been only discovered by dissection. In Lonsdale's, it had not even been suspected during life; there was no displacement, and the swelling occurring around the joint had been attributed to a severe sprain; but the inflammation ran so high as to destroy life on the twelfth day. M. Rognetta says that he twice saw simple fractures of the astragalus, without any displacement, or any injury of the soft parts; at the instant of the accident, or even after the swelling had subsided, he detected the lesion by the sensation imparted to the touch, *like that of several nuts in a bag*. The fracture must therefore have been multiple. Both these patients having recovered readily, the diagnosis could not be verified by dissection.†

[It may be doubted whether the multiple character of these fractures was proved by the sensation alluded to, since it is well known how completely the most delicate touch may be deceived; and especially where effusion into the articular cavity would increase the chances of error.]

Sometimes one of the fragments projects outward; and as in that case it is separated from its ligaments, the lesion is commonly considered in connection with luxations of the bone. But I know of no other case analogous to that seen by Rumsey, in which the upper fragment, retaining its relation to the bones of the leg, protruded with them through a large wound. Rumsey disarticulated and removed this piece, thus converting the injury into a tibio-tarsal luxation; and this is doubtless the reason why Sir A. Cooper has as it were misplaced this curious case in his account of these luxations. The patient recovered in the space of three months.

§ II.—*Fractures of the Calcaneum.*

There are two very distinct varieties of these fractures: rupture by muscular action, and crushing.

Until the publication of my memoir concerning this latter injury,

* *Bulletin de la Soc. Anatomique*, 1843, p. 170.
† *Archiv. Gén. de Médecine*, 1833, tome iii, p. 498.

the former was the only one recognised; it is described by all the classic authors; and what is curious, not one of those who thus described it pretended to have ever seen it. It may therefore be safely presumed that imagination played a more prominent part than reality did in their descriptions. The cases were indeed of rare occurrence; I have myself been able to collect only eight, and those mostly very incomplete.

The first was published by Garengeot, in 1720. A man fractured his calcaneum by falling into a sewer; Poncelet, being called to see him twenty-four hours afterwards, opened a little swelling due to extravasation of blood, saw at the bottom of this the posterior fractured portion of the bone, *and finding that the piece was not firm, cut the tendo-Achillis which held it, and extracted it.* The patient is said to have recovered, and to have walked as well as ever.*

Some writers, with Heister at their head, have asserted that in the case just alluded to the tendo-Achillis was divided with a view of favoring the approximation of the fragments; but of this it is evident that Poncelet never dreamed. According to Garengeot's account, we may consider it to have been a fracture by crushing, such as that in *Fig.* 93; but J. L. Petit, to whom Poncelet showed the case, says expressly that it was the result of retraction of the tendo-Achillis.

J. L. Petit, in a memoir read before the *Académie des Sciences*, in 1722, cites an analogous instance; "Madame la présidente de Boissise," says he, "made a false step, and retracted the tendo-Achillis so forcibly as to break the heel-bone."

After this come two cases observed by Desault, one of which is reported by Richerand, and the other by Bichat. In each, the fracture was due to a fall from a height, the toes striking first. These were the only ones bequeathed to science by the eighteenth century, and Boyer knew of no others. Since then there have been published in succession one case by Bottentuit, one by Assalini, one by M. Lisfranc, and one by Custance.†

If we seek to derive some conclusions from these cases, we find in the first place as to the causes, that the fracture was twice the result of a false step; once by the upsetting of a wagon, the heel being caught between it and the ground; five times by a fall from a height, alighting on the feet. The special circumstance of the fall being on the toes is only noted in Desault's two cases.

The fracture is always seated behind the astragalus. But is the bone broken vertically, so that the two inferior tuberosities are both comprised in the detached piece? or is any other direction assumed?

* Garengeot, *Traité des Opérations.*

† Bottentuit, *Journ. Gén. de Médecine*, tome xxiv, p. 377; Assalini, *Manuale di Chirurgia;* Lisfranc, *Archiv. Gén. de Médecine*, tome xvi, p. 109; Custance, *ibid.*, tome xxi, p. 124.

or, finally, is there only a tearing off of the portion of bone into which is inserted the tendo-Achillis? We have no positive data on this subject. In Poncelet's case the fracture occupied the posterior part of the bone; Richerand also speaks of a posterior fragment; Bichat calls it *exterior*, which is very vague; but it should be remarked that none of these three writers had witnessed the cases. Bottentuit says that the bone was broken at its *upper extremity;* M. Lisfranc speaks also of a fracture of the *upper and posterior portion;* but Custance states distinctly that the *posterior part* of the bone was involved, *immediately below the point of insertion of the tendo-Achillis.*

The fracture is almost always single, that is to say, free from splinters; M. Lisfranc's case forms the only exception to this rule.

The detached fragment is drawn more or less backward and upward by the muscles connected with it, by the contraction of which it was torn off. The extent of this displacement is very variable; it was almost nothing in Poncelet's case, and in Bottentuit's it amounted to only half a finger's-breadth; in that of Custance, on the contrary, it was very great; the fragment was removed five inches from its natural position, or as is subsequently explained, from the bottom of the heel. This interval would of course be increased by extension of the leg and flexion of the foot, and diminished by flexion of the leg and extension of the foot. Desault and Assalini succeeded in obtaining perfect contact, by means of the latter position. Neither Lisfranc nor Custance were so fortunate; but it is not said that they attended to the position, and some of the details of their cases would seem to indicate the contrary.

In one case, the skin was ruptured as well as the bone; a circumstance not clearly accounted for. In three there was severe pain, and in one of these there was inflammation ending in gangrene. It should be remarked that these symptoms are not mentioned in connection with those cases in which the limb was put in a rational posture.

The fragments once placed in contact, consolidation takes place without difficulty. It was completed by the forty-seventh day in one of Desault's patients; in the woman treated by Lisfranc, the detached portion was at first reunited by fibrous tissue, but in the end it became immovable, which would apparently prove the connection to be bony. Even without such union, the consequences are less grave than we might be led to suppose; Poncelet's patient walked none the worse, although the fragment in his case had been removed; and Custance's, in spite of the great separation, reduced hardly half an inch by contraction of the cicatrix, could walk five years afterwards without pain or apparent inconvenience, and wearing an ordinary shoe; in a word, as well as ever. Some exaggeration may be suspected in this account; but we may infer at least that the gait,

even in the most unfavorable cases, is not seriously and permanently affected.

The diagnosis would seem never to have presented any very great difficulty. The separation of the fragments when the leg is extended, their approximation, and the crepitus rendered perceptible by it, when the leg is flexed, and lastly the free mobility of the detached portion, can hardly leave any room for doubt.

The prognosis, judging from the cases known, is by no means grave.

The entire treatment is based upon two indications: the first, and by far the most important, is to keep the foot extended and the leg flexed; the second, hitherto neglected, is to make direct pressure upon the fragments, so as to keep them in contact and hasten consolidation.

To meet the first indication, recourse may be had to any of the contrivances for rupture of the tendo-Achillis. J. L. Petit used at first a sort of uniting bandage, made with pieces of a common roller; Desault added a compress, to be placed transversely above the upper fragment, and to aid in bringing it downward. Such pressure would have rather the effect of pushing it forward among the deep muscles of the leg; besides which, the bandage would have the serious disadvantage of being apt to relax.

For this reason Petit himself abandoned it. He fitted the injured foot with a slipper, to the heel of which was attached a long strap; this strap passed upward to be wound upon a windlass fixed at the back of a leather knee-piece, embracing the limb above and below the knee. Monro simplified this apparatus, fastening the strap by means of a buckle to a sort of half-gaiter laced around the calf of the leg; but by this plan the advantage of flexion of the knee was lost. Thillaye conceived the happier thought of having a firm band pass upward from the heel of a shoe of leather or muslin, to be buckled to the back of a garter or circular band surrounding the limb above the knee.

I shall say nothing of the splint applied by Monro over the front of the leg and back of the foot, so as to keep the foot extended, except that he was himself unable to tolerate it.

Thillaye's apparatus is certainly the simplest and the most efficient of all, the sole of the shoe being made very solid, so that the toes shall not be subjected to undue pressure when the strap is tightened. Boyer, indeed, objects that if the fracture were vertical the sole would have the effect of pushing up the fragment, which should be drawn down. This is true in the case supposed, and it would then be necessary to have the sole somewhat bent, so as not to bear upon the heel. Or we might, with still greater simplicity, keep the leg very strongly flexed on the thigh, by passing a folded handkerchief beneath the sole of the foot, crossing its ends over the instep, and then making it

surround the leg and thigh, knotting it in front of the latter. In all cases the leg should be laid upon its side.

As regards the second indication, it is perfectly fulfilled by passing a strip of plaster around the heel, and crossing the ends over the instep; and there is no need of dwelling upon it further.

Another form of this fracture, much more common than the preceding, is that by crushing. It had been completely lost sight of at the time when my memoir was published; but since then the instances of it have multiplied, and all surgeons have learned to recognise it.*

Almost the only cause producing this lesion is falling on the heel; M. Huguier, however, has shown me one case in which it was due to lateral pressure, the integuments remaining intact; it had not been diagnosed, and was discovered only by dissection. A fall upon the heel may occur under various conditions; it may be that only the posterior portion is struck, and then the lesion will affect it alone, as in *Fig.* 93; or the heel may come down almost flat, which is most generally the case. Lastly, both heels may strike at once, and both bones be broken; of this I have seen one instance, and another has been reported by M. Voillemier.

If a calcaneum so fractured be carefully examined, it will be seen that the crushing may take place in different degrees. *Fig.* 99 represents it as it occurred from a fall out of a window which was only breast-high; the upper face of the bone is shown. A horizontal fracture, beginning at the base of the greater articular facette, has first divided it into two portions, one above the other; the anterior end of the upper of these is driven into the spongy tissue of the other to a depth of four or five millimètres. This upper fragment is again divided into two by an antero-posterior fracture; and these two fresh fragments are separated in front by an interval of four or five millimètres. The inner one, which alone was movable, gave rise during life to indistinct crepitation; all the others, including those of the anterior part, those of the inner face and those of the lower face of the bone, were so retained in place, either by the investing fibrous tissues or by their mutual interlocking, that it was impossible to elicit from them the slightest crepitus.

On the whole, the bone was crushed from above downward, and was diminished in thickness; at the same time its fragments were separated so as to increase its width. Thus at the posterior edge of its larger articulating facette, its thickness was only four centimètres, and on a level with its lesser tuberosity its width was fifty-five millimètres.

Figs. 98 and 100 represent a larger calcaneum than the preceding, crushed by a fall of seven or eight yards. The thickness of the bone

* Malgaigne, *Mémoire sur la fracture par écrasement du calcanéum; Journal de Chirurgie*, Jan., 1843; *ibid.*, 1843, pp. 63, 92, 376; and 1845, p. 154.

at the posterior edge of the larger articulating facette was reduced to three centimètres; its width opposite the lesser tuberosity was sixty-five millimètres. The corresponding bone of the other foot, crushed by the same fall, presented almost exactly similar alterations in its thickness and width.

The symptoms are, in the first place pain of such severity as to prevent the patient from walking; although if the crushing is but slight, he may be able to limp along a little. This is what took place in the subject of *Fig.* 99, who fell but a short distance, and in M. Béringuier's patient, who fell from a height of about six feet. Almost simultaneously with the pain there comes on swelling, involving both malleoli, the instep, a portion of the back of the foot, the sides of the foot below the malleoli, and a portion of the sole of the foot; what is remarkable, the heel and the region of the tendo-Achillis are exempt. This swelling so completely masks the deformity, that an inexperienced eye would think the foot free from injury; and it is so marked over the malleoli, especially the inner one, as to almost irresistibly attract attention to that part. But over the malleoli, as well as on the back of the foot, it is soft and compressible, while below the inner malleolus it rests on an abnormal bony prominence, formed by the lesser apophysis of the calcaneum. The ecchymosis, at first scarcely perceptible, becomes more marked after the lapse of some days; it may cover the lower third of the leg, but is chiefly situated below the malleoli. Here too the most pain is caused by pressure, at first at the inner side, then at the back of the heel; sometimes over the malleoli themselves. Crepitation is obscure, and often wanting; the best way to elicit it is by moving the calcaneum in different directions, and especially by rotating it, or by carrying it from side to side. The two characteristic deformities are: the increased width of the bone, perceptible by close inspection, but especially to the touch, below and a little in front of the inner malleolus; and the falling of the arch of the foot, sometimes evident to the eye, and at any rate felt by the hand when the soft parts at the back of the foot are pressed downward. This sinking in may also be verified by measurement; thus M. Béringuier, comparing the two sides in regard to the distance between the apex of the outer malleolus and the sloping part of the heel, found that on the injured side it was lessened by one centimètre. The same practitioner has likewise observed the heel to be elongated backward; by measuring the foot from the heel to the great toe, he detected an increase in length of one-third of an inch; and a tape, carried around the heel from one malleolus to the other, showed also an excess of half an inch. Still, in another patient, M. Moré sought in vain to discover any sign of this elongation; possibly because the crushing was less severe.*

* Béringuier, *Journal de Chirurgie*, 1843, p. 376; Moré, *ibid.*, 1845, p. 154.

The first time that this fracture came under my notice, I mistook it for a fracture of the fibula, without displacement, and complicated with a sprain. The same error was committed in Voillemier's case; and M. Bonnet of Lyons was himself misled in the same way, being, like myself, only undeceived by the dissection of the part. It may be avoided by noting carefully the point where pressure is painful, by using the means alluded to for eliciting crepitus, and above all by observing, both by the touch and by measurement, the projection inward of the calcaneum and the sinking in of the arch of the foot.

Even after the calcaneum is known to be broken, there may remain some doubt as to the complications,—some suspicion, for instance, of fracture of the malleoli or of the astragalus. I would say in the first place, that such complications are very rare; fracture of the astragalus, indeed, has never been to my knowledge seen in this connection;* and besides, we may press directly on the head of this bone, after the example of M. Moré, and ascertain whether such pressure develops either crepitation or pain.

The course of these fractures is sometimes unfavorably influenced by cerebral symptoms, resulting from the concussion of the fall itself. Some patients complain of extremely acute pains at the seat of injury, persisting for four or five days, or even longer; this is particularly the case with those who have been subjected to traction on the foot in order to correct the displacement, and is probably due to malposition of some splinter.

Consolidation takes place slowly. *Fig.* 99 shows a fractured calcaneum at the thirteenth day; those in *Figs.* 98 and 100 were at the forty-eighth; in *Fig.* 98 we observe a total absence of reparative action on the exterior, and in *Fig.* 100 the callus in the interior is seen still to present numerous lacunæ. It is therefore a good while before the free use of the limb is recovered. M. Moré's patient began to walk at the end of six weeks; but for more than a year he was subject, after any excess in walking, to tearing pains in the foot, accompanied by heat and swelling. M. Béringuier's patient still had, after two months, pain in walking over an uneven surface; M. Voillemier's, who had had both calcanea broken, was under treatment for seven or eight months before he could walk, with the aid of a stick, for twenty minutes.

The ultimate results have been investigated in two patients; in one by M. Moré, after the lapse of about fifteen months, and in the other by M. Voillemier, after thirteen years. The former could walk more than twenty miles a day, but he limped a little, instinctively tending to put the foot down by its middle part or sole. If, indeed, he rested his weight upon the heel, he felt as if the ground were

* [I have recently seen two dried preparations of fractures involving both the calcaneum and astragalus; one of them was caused by a railroad injury, and the other, I believe, by a fall upon the heel.]

giving way; if on the contrary he bore upon his toes, it gave him great pain in the tibio-tarsal joint, which still remained a good deal stiffened. Voillemier's patient had by degrees learned to walk quite easily, and for a good while, without limping, by means of high-heeled shoes. His heels being thus raised, the feet could be flexed to a useful degree; but he had to be careful not to carry this too far; since, for example, if the foot were set flat upon the ground, and there were under its anterior part a projecting body, even of no greater volume than a nut, the excessive flexion would give rise to intense pain in the ankle-joint. For the same reason, while he could still jump from below upward, it was almost impossible for him to jump down the distance of one yard. The functions of the foot were therefore pretty nearly restored, though they were still by no means in the normal condition. On the whole, there is left after the cure of this fracture more or less flatness of the foot, with stiffening of the tibio-tarsal articulation, or rather perhaps of those of the astragalus with the scaphoid and calcaneum.

The prognosis, it is evident, is not without gravity, which is proportionate to the amount of crushing.

The treatment is extremely simple. It is unsafe to try to lessen the flattening of the bone by drawing down the heel, and therefore the only indication is to keep the foot at rest and in good position, until consolidation is complete. I make use at first of two lateral splints, as in fractures of the leg, in order to watch the progress of the swelling, and if necessary to combat it. This having subsided, it is well to employ an immovable apparatus, enabling the patient to get up and go about on crutches. He should wear this apparatus for at least forty-five days, after which the joints of the foot may be exercised, to avoid subsequent stiffening; but it is safer for him to wait till the end of the second month before trying to put the foot to ground, and then care should be taken to make up as much as possible for the flattening of the heel, by thickening the heel of the shoe to a proportionate extent.

§ III.—*Fractures of the Metatarsal Bones.*

These fractures are very rare; scarcely three or four cases occurred in the Hôtel-Dieu during the eleven years which we have studied; and judging from this very small number of facts, the fourth and fifth bones are more frequently involved than the others, doubtless by reason of their greater slenderness. The lesion is almost always due to direct violence, and hence is attended with contusion, or even with a wound; sometimes there is a real crushing; lastly, M. P. Bérard has seen the fifth metatarsal fractured near its posterior extremity in consequence of a fall on the feet.

The nature of the injury is recognised by the local pain, by the projection upward of the posterior fragment, and by the crepitation. If the last-named sign is not perceived by pressing with the finger over the supposed seat of fracture, it may be produced by grasping the corresponding toe and moving it in different directions.

Not unfrequently the diagnosis can be only a probable one, all the phenomena being absent except the local pain. It is quite rare that even the displacement is well-marked, the sound bones serving not only as a partial protection from external violence, but also subsequently acting as splints. But when two or three bones at a time are involved, this defence is taken away, and the displacement may be extreme. I recently had to treat a carter, who was thrown down under his vehicle, and had the three middle metatarsal bones broken by the wheel passing over them. The anterior fragments were very greatly depressed; there was a lacerated wound on the back of the foot, and the inflammation was most intense. It was therefore impossible to remedy the displacement, and indeed the saving of the foot could hardly be hoped for. The patient recovered, and could plant his foot very firmly on the ground, but the great projection of the upper fragments at the back of the foot obliged him to wear a shoe of a particular shape.

For fracture without displacement, rest is almost the only remedy, and a lightly applied immovable apparatus will enable the patient to walk about as soon as the inflammation has subsided. Any displacement that may occur should be corrected by the same contrivances as those for fractures of the metacarpus, and thirty days at most will suffice for consolidation. The instance above mentioned shows that even the worst cases should not be too readily given up as hopeless. Delamotte met with similar success in a man who had had the first four metatarsals divided by a blow with an axe. Union was complete by the fortieth day, but the patient was not allowed to walk until the end of the second month; and the foot became so firm that when he stamped on the ground alternately with it and the sound one, they could not be distinguished from one another.*

§ IV.—*Fractures of the Phalanges of the Toes.*

These commonly occur by crushing, and are only called fractures when the destruction of the tissues is not very considerable; hence their apparent infrequency, in consulting our figures from the Hôtel-Dieu. Only ten are recorded for the eleven years, and in seven of these ten the great toe was the one involved. All the patients were men.

* Delamotte, *Traité de Chirurgie*, obs. 384.

I have six times seen fracture of the first phalanx of the great toe, always resulting from the fall of some heavy body, but never attended with an external wound. There was no appreciable displacement; the pain first directed my attention to the part, and the crepitation, always readily produced, gave certainty to the diagnosis. A small splint at the plantar face, fastened by two strips of adhesive plaster, answered the purpose in each case; only it is important to pad the splint sufficiently, and to put a somewhat thicker compress under the second than under the first phalanx, so as to preserve the normal form of the toe. Consolidation takes place in twenty-five or thirty days.

As for fractures of the other toes, I have never seen them except with such destruction of the soft parts as to necessitate either the removal of the anterior fragment or the amputation of the toe. In the smaller toes this operation is not very dangerous; in the great toe it involves much more of a risk, since among forty-three such amputations for injuries, done in the Parisian hospitals from 1836 to 1841, seven deaths occurred. This is an imperative reason for limiting the extent of the amputation, when it becomes necessary, as much as possible; the removal of the last phalanx, for example, involves hardly any danger at all.

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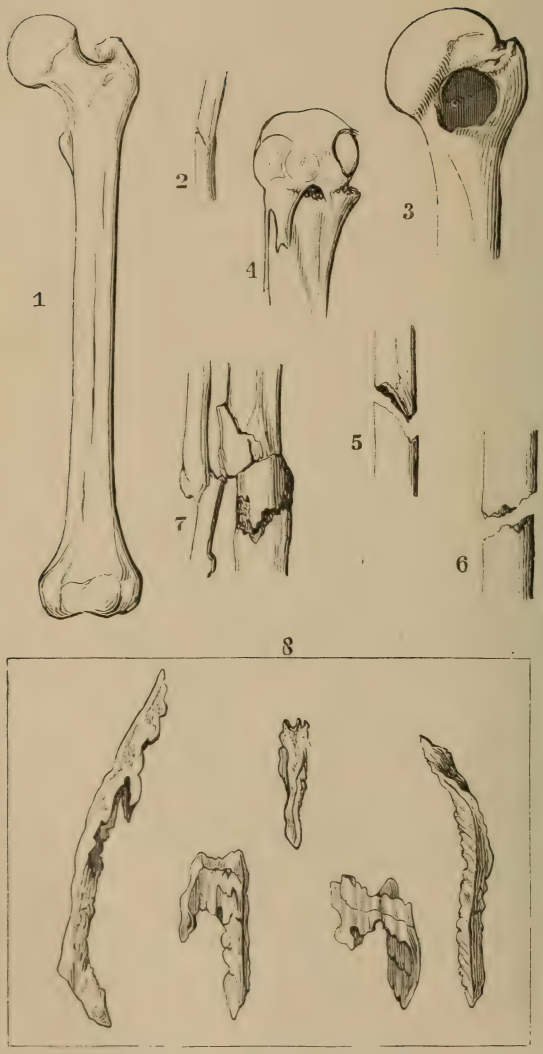
PLATE I.



EXPLANATIONS OF THE FIGURES.

PLATE I.

FIG. 1.—*Fissure of the femur.* (*Museum at Val-de-Grâce.*)—This bone belonged to a very large man; it measured forty-four centimètres [about sixteen inches] from the top of the head to the inner condyle; and in its upper portion the wall of the shaft was five to eight millimètres [one-sixth to one-fourth of an inch] in thickness. On its anterior face is seen a long vertical fissure, irregular here and there, but single, and thirteen centimètres [four and one-third inches] in length. Immediately below this is another one, very small, about one-third of an inch long; above it are two others, each an inch or so in length, and another is situated a little less than two inches above the knee-joint.

On the inner face of the bone, in its lower third, there is another fissure an inch long; on the outer face, near the linea aspera, there is a series of five fissures, altogether about sixteen centimètres [five or six inches] in length. Those of the anterior face only are represented.

There is nowhere found any mark of external violence; nor can any history be obtained of this singular specimen.

The bone being sawed open from above downward, the largest fissure was plainly seen to involve the whole thickness of the wall; no sign of the others could be detected interiorly.

FIG. 2.—*Incomplete fracture of the ulna, produced on the dead subject.*—I am now in possession of a similar fracture of the same bone, recognised during life, and rendered certain by *post-mortem* dissection.

FIG. 3.—*Perforation of the upper extremity of the right humerus by a ball.* (*Museum at Val-de-Grâce.*)—The bone is viewed upon its outer and somewhat posterior aspect, the epicondyle looking forward and somewhat to the right.

A ball of ordinary size has penetrated the neck of the bone, close to the lower attachment of the capsular ligament, forming quite a regular cavity, without a trace of any other fracture. The ball was not extracted, but was found upon the dead body long after the time of the injury; it had preserved its form, except a small fragment which was found incrusted in the upper wall of the cavity in the bone.

This cavity, which is seen somewhat obliquely in the figure, was twenty-eight millimètres in vertical diameter at its orifice, and more than forty within; twenty-five millimètres in transverse diameter at its orifice, including the notch, and thirty within. It occupied all but about three to five millimètres of the thickness of the cervix humeri, the anterior wall of which is seen to be perforated by a small orifice. The interior of the cavity was quite regular, bounded throughout by areolar or spongy bone, and without communication with the medullary canal. Its *bas-fond*, so to speak, was one centimètre below the lower edge of the orifice, and the ball, resting on this floor, filled only about one-third of the whole cavity.

It is to be regretted that we have no information as to the date or course of the injury, nor as to the condition of the soft parts upon dissection. Was this large excavation made at the first, by reason of the rotary motion of the ball, or did it result from a slow process of absorption of the bone around the ball, by a sort of vital dilatation? I incline to the latter opinion, chiefly because of the regularity of the inner surface of the cavity.

FIG. 4.—*Disjunction of the superior epiphysis of the humerus.* (*Musée Dupuytren*, No. 91.)—M. Champion's specimen, described at page 72.

FIG. 5.—*Oblique fracture of the humerus, produced upon the dead subject.*

FIG. 6.—*Serrated fracture of the femur, produced upon the dead subject.*—Compare with *Figs.* 76 and 77.

FIG. 7.—*Fracture of the tibia, with a cuneiform splinter, combined with a double fracture of the fibula.*—A woman aged 50, had her right leg caught under a cask of wine, and sustained a fracture with a lacerated wound, exposing the lower fragment of the tibia to the extent of over an inch. This lower fragment could not be kept in place at all; (I had not then contrived my screw apparatus;) granulations soon sprang up around the denuded portion, which became necrosed; about the fifteenth day the symptoms of purulent absorption set in, attended with colliquative diarrhœa, and the patient died on the twentieth day.

The fibula is seen to be broken in two places: the middle fragment riding up upon the inner face of the superior one, but carried somewhat to the outside of the inferior; a reddish tissue studded with little bony points shows the progress of the work of repair.

The tibia presents two pointed fragments, with a wedge-like splinter detached from its inner surface, and displaced outward into the interosseous space. The whole substance of this splinter is penetrated by vessels, except a small triangular necrosed bit just at its summit. The upper fragment of the tibia is likewise ridged with numerous vessels, and both the inner and outer face present little bony prominences of new formation, showing that the repair was begun. On the contrary the whole of the denuded portion of the lower fragment is hard, white, *killed;* its edges are serrated, and have a worm-eaten appearance: the sound tissue bordering it is hollowed out to the depth of one or two millimètres. This hollow was filled up by a soft, reddish membrane, which was prolonged under the edge of the necrosed portion, and which during life had the usual aspect of granulations. Its adhesion to the subjacent bony tissue was but slight: that which is seen naked in the figure was reddish, but very hard; and presented a great many longitudinal *stripes of bone*, sending out small lateral branches to one another, and separated by ridges of a deeper red color, easily cut with a knife. They resembled the normal fibres of the bone, dissected, isolated and rendered prominent by the development of fine vessels in their interspaces. Lower down, the fragment resumed its normal thickness; but it was studded with very numerous points of vascularity, giving it a deep rose-color.

FIG. 8.—*Splinters from a gunshot fracture of the tibia received in* 1815, *discharged through fistulous orifices in* 1823. (*Museum at Val-de-Grâce.*)—All these splinters are white, compact, and seem as if split off from the thickness of the wall of the shaft. In three of them,—the two largest and the middle-sized one,—the external face of the bone is easily recognised, hardly at all affected by absorption. The largest is traversed by a spiral fissure, not involving its entire thickness.

PLATE II.

FIG. 9.—*Fractures of the ribs of the right side.* (*Musée Dupuytren*, No. 8, *a.*)—These fractures, resulting from violent pressure, involve eight ribs, from the second to the ninth inclusive. They are all single, that is, each rib is broken at but one point; there is overlapping in most of them; and the narrowing of the lower intercostal spaces is such that the sixth, seventh and eighth ribs are soldered together. The specimen is described at page 352.

FIG. 10.—*Incomplete fracture of the fifth rib, with complete fractures of the fourth and sixth, on the right side.*—These lesions resulted from a fall against the arm of a sofa; the third and seventh ribs were broken at the same time. Death ensued on the third day. The inner aspect of the specimen is represented; the three fractures are seated at nearly the same distance from the cartilages, but the upper and lower one present a prominence inward of the posterior fragment, while in the middle one, involving only the external table, the internal table is seen bent inward, forming an angular prominence. See page 347.

FIGS. 11 and 12.—*Fractures of the sternum*, found in a dead subject by M. Huguier.—In *Fig.* 11 the anterior aspect of the bone is presented, showing the irregularity of the edge of the lower fragment, which has passed up in front of the other. *Fig.* 12 represents a vertical section of the bone; the overlapping is seen to be only partial, and accompanied by angular displacement forward, which affects chiefly the lower fragment.

PLATE II.

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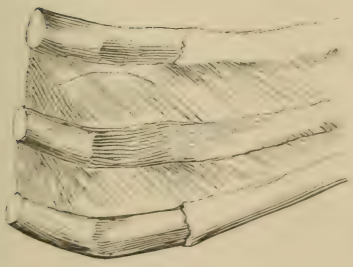

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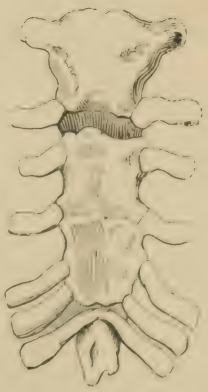

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PLATE III.

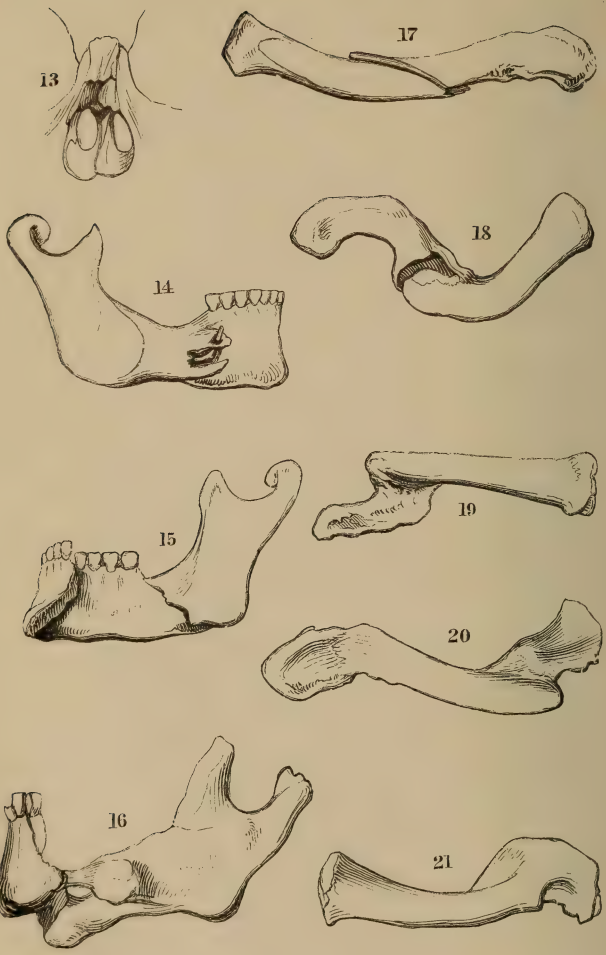


PLATE III.

FIG. 13.—*Fracture of the nose, with marked lateral displacement of the lower fragment.* (*Musée Dupuytren.* No. 39.)—A full description of this specimen is given at page 293.

FIG. 14.—*Recent fracture of the lower jaw.*—This specimen was taken from a man who threw himself from a height of two stories, and was instantly killed. The fracture is oblique forward and outward: the posterior fragment, bevelled off at the expense of its inner face, has overlapped the anterior to a considerable extent; an overlapping undoubtedly favored by the absence of the teeth in the former. I have made a notch in the bone in order to ascertain the state of the inferior dental nerve: it proved to be perfectly intact, the overlapping having prevented its stretching, and the resulting separation of the fragments, its being pressed upon.

FIG. 15.—*Recent double fracture of the lower jaw.*—The middle fragment is formed almost entirely from the left half of the bone. The posterior fracture runs obliquely outward and forward, as in the preceding case, and the displacement is also similar; but the anterior fracture, besides its very apparent obliquity downward and inward, divided the bone in its thickness in such a way that the middle fragment is at its upper part bevelled at the expense of its inner table, and at its lower part, at the expense of its outer table. It was driven backward by the external violence, and moreover pulled downward by the muscles. Reduction could not be effected; the bevelled edge of the right half of the bone riding over that of the middle fragment, prevented the latter from being drawn forward. See pages 309 and 313.

FIG. 16.—*Double fracture of the lower jaw, with depression of the middle fragment, and vicious consolidation.* (*Musée Dupuytren.* No. 53.)—This fracture was caused by a charge of small shot fired from a gun: the middle fragment is driven backward and drawn downward, as in the preceding case; but here the fragment has also undergone such a change of position, that its lower border is inclined forward, and its outer face looks almost directly upward; consolidation has taken place, giving permanence to these displacements, as well as to a marked approximation of the left posterior to the right and anterior fragment.

In this case the dental nerve was ruptured, and its canal obliterated at the seat of fracture. See page 310.

FIG. 17.—*Recent fracture of the left clavicle, with great obliquity.*—The bone is represented with its upper face inclined somewhat forward, so as to show the direction of the fracture, forward and outward. The patient died of other lesions, almost immediately after the accident.

FIG. 18.—*Fracture near the middle of the clavicle, with angular projection and pseudarthrosis.* (*Musée Dupuytren.* No. 50.)—The line of fracture seems to have been inward and backward. The sternal fragment is carried upward and forward, the acromial downward and backward; there is a very marked overlapping: terms which express the three usual displacements. But one great difference between this specimen and the others is, that there has been no bony union, or in other words, a false joint has been formed; another is the strange shape of the bone, which is such that, even putting the two fragments end to end, we should not have a normal clavicle. This is because the sternal fragment, instead of being nearly straight, or forming a gentle curve from one extremity to the other, presents an exaggerated convexity forward, and posteriorly a hollow half an inch in depth. Its outer extremity would seem to have been gradually bent backward by the motions of the false joint, or perhaps its anterior prominence was absorbed: so that in place of a projection forward of this fragment alone, we have an obtuse angle formed by the two.

However this may be, besides the three chief displacements mentioned, the acromial fragment is lowered at its outer end, and perhaps its posterior border is somewhat higher than the anterior.

FIG. 19.—*Fracture of the clavicle, near the acromial extremity.* (*Musée Dupuytren.* No. 55.)—This fracture would seem to have been somewhat oblique backward and inward; it has divided the bone internal to the insertion of the coraco-clavicular ligaments. The acromial fragment has descended below the other by more than two centimètres; it is also carried backward, and the anterior angle of the sternal fragment forms a very marked projection forward. Lastly, the overlapping exceeds two centimetres, and the bone is very much shortened. A thick callus, pierced from above downward with a smooth hole, connects the posterior edge of the acromial fragment with the body of the bone; it extends about an inch along the latter.

FIG. 20.—*Double fracture of the clavicle.* (*Musée Dupuytren.* No. 65.)—One of these fractures, seated about an inch from the sternal end of the bone, seems to have been oblique outward and backward: the outer fragment has consequently slipped down somewhat, and very much forward, its point projecting nearly two centimetres in front of the other. The second fracture is seated about an inch from the acromial end: it seems to have been oblique downward and outward, so that the outer fragment has ridden up somewhat over the other, without notably deviating either forward or backward. The greater part of the coraco-clavicular ligament was still adherent to the inner, or more strictly speaking to the middle fragment. Perhaps there is a slight obliquity of the acromial fragment downward and inward. All this is evidently due to the obliquity of the fracture.

As regards fracture near the sternum, I should state that there is only one other example of it in the Musée Dupuytren, (No. 64;) this fracture is single, but as it presents the same phenomena, I have not had it represented.

FIG. 21.—*Fracture near the acromial extremity.* (*Musée Dupuytren,* No. 56.)—This specimen was presented without history, by Professor Thillaye. The fracture seems to have been somewhat oblique backward and inward, and to have divided the bone just at the junction of its body with the acromial portion, the posterior angle of which is still part of the outer fragment; it is therefore just inside the inner edge of the coraco-clavicular ligaments. The outer fragment has descended about one centimètre; but it is also carried backward and inward, so that the inner one is entirely in front of it, making a very marked projection, and shortening the bone by more than one centimètre. A broad, flat, triangular callus, unites the acromial fragment to the body of the bone posteriorly, and is prolonged inward for three centimetres along the latter.

Here, as in *Fig.* 19, there is seen a triple displacement: the lowering of the acromial fragment, the overlapping, and the projection forward of the sternal fragment. This latter is about the same in both instances; the two other displacements are in the present case much less marked. It should be added that here the acromial fragment has descended *en masse*, remaining parallel to the other; while in *Fig.* 19 it is somewhat oblique, its outer end being a little lower than the other.

PLATE IV.

FIGS. 22 and 23.—*Multiple fractures of the scapula, and fracture of the cervix humeri.*—Specimen presented by M. Voillemier. The scapula is broken in its body, in its neck, across the glenoid cavity, in the acromion and in the coracoid process.

(1.) The fracture of the *body of the scapula* separates nearly the whole of the inferior third of the bone. It describes an arc convex superiorly, so that the upper edge of the lower fragment is also convex. (See *Fig.* 23.) The upper fragment is divided into two parts by another fracture, which has detached the whole outer edge and glenoid cavity from the rest of the bone, following the line of the cervix; another quite voluminous fragment, comprising the upper half of the cervix and the summit of the glenoid cavity, has been separated both from the preceding piece and from the base of the coracoid process; which base itself, with a small portion of the upper edge, has been separated from the body of the bone. There are thus in all four large fragments separated from the body of the bone, not counting those of the point of the coracoid process and of the acromion, to which allusion will be made directly.

On the one hand the two pieces first named are carried outward, leaving quite a large space between them and the body of the bone: it is a displacement by separation, hitherto not pointed out in this region, but of undoubted reality. It might at first be thought that the interspace was increased by the loss of some splinters too small to be kept in place, one of which is however seen firmly united. But a careful study of the specimen shows that the salient angles of each fragment correspond exactly to the entering ones of the others, and that, but for several masses of callus which have been thrown out, they might be fitted to one another without any apparent loss of substance. These two fragments are therefore drawn outward, and the body of the bone seems to have tilted a little upward and inward, so as to favor the resulting separation.

The lower fragment is in consequence carried considerably within and in front of the outer one, which consists of the edge of the bone. (*Figs.* 22 and 23.) and at the same time it has ridden up by nearly two centimètres. Besides this triple displacement, seen in the drawing, there is a fourth which could not be there represented. The outer fragment is tilted backward at its lower part, so that, if prolonged to the level of the inferior angle of the bone, it would be nearly six centimètres distant from the latter. This angle and the fragment to which it belongs, on the contrary, are very nearly in the same vertical direction with the rest of the body of the bone.

On the other hand, the outer fragment, comprising the greater part of the glenoid cavity, projects forward one or two centimètres at its upper end. (*Fig.* 23.) It is so also with the coracoid fragment, which seems tilted backward, so that a marked interval is left between the edges of these two pieces. This separation is kept up by an intermediate bit, which seems wedged in between them posteriorly, (*Fig.* 22.) and which moreover aids in keeping the glenoid fragment apart from the body of the bone.

Such is the multiple character of this fracture, in which the displacements are so numerous and varied that neither pen nor pencil can completely set forth their different shades and directions. Enough has been said however to give some idea of them.

Traces of callus are seen especially where the bone has some thickness, between the lower fragment and the side of the bone, and about the triple fracture of the cervix. There are some signs of it on the inner or posterior edge of the bone, where however the fragments are at some distance apart: and lastly, the consolidation of the little splinter near the middle shows that the difficulty lay not in the thinness of the bone, but in the interposition of the periosteum.

(2.) The fracture of the *acromion* is transverse, seated just behind the articulation with the clavicle. (*Fig.* 22.) The outer fragment has sustained a curious displacement; it projects posteriorly five or six millimetres more than the other, from which it is there separated a little more than in front. It is at the same time depressed about one millimetre, but without any marked inclination of its point. The upper edges of this fracture show roughnesses denoting the commencement of the callus, which however could not fill up the interspace between the fragments; their connection is by fibrous tissue.

(3.) The fracture of the *coracoid process* is irregular, and seated about two and a half centimètres from its point; one little bit of it was divided into two, which were at one side united by solid callus; very slight traces only of fibrous tissue could be detected elsewhere.

(4.) Fracture of the *cervix humeri*. Let us note first that the humerus displays a transverse fissure of its cartilage, (*Fig.* 23;) another one, vertical in its direction, is not represented in the cut. This latter hardly involved more than the cartilage; but the other penetrated to a depth of nearly an inch.

The [surgical] neck of the humerus is also fractured obliquely, the division beginning at the inner side, an inch from the head of the bone, and running downward and outward to terminate two and one-third inches from the summit of the greater tuberosity. The specimen shows several serrations and small splinters, not to be distinguished in the cut from the rudiments of the callus; the displacement has taken place somewhat inward, the inner wall of the superior fragment being caught in the medullary canal of the inferior. This canal shows no traces of callus; that of the upper fragment contains some small bony stalactites. The *débris* of the callus, where the fibrous tissue has been eaten away by insects, may be also seen; and an osseous formation of notable size, resembling the callus, at the place of attachment of the deltoid, about four and a half inches below the seat of fracture, is prolonged up to the latter point by small deposits of callus. In fact, the callus is traceable for a distance of six centimètres downward from the seat of fracture.

FIG. 24.—*Transverse fractures of the body and lower angle of the scapula.*—This specimen was taken from a young epileptic at Bicêtre, who a long time before his death sustained a fall upon his back. It is described fully at page 403.

FIG. 25.—*Fracture of the acromion.* (*Musée Dupuytren*, No. 67.)—This specimen came from Desault's collection. The fracture is a straight one; commencing posteriorly just behind the scapulo-clavicular articulation, three centimètres from the extremity of the acromion, and terminating in front at the corresponding point. The outer fragment is inclined downward, separating from the other above only, as if the periosteum at the under surface had resisted the violence which ruptured that at the upper. The fracture was one of long standing, its upper edges being apparently heightened by the formation of an abnormal bony crest, particularly prominent upon the scapular fragment. No consolidation had occurred, nor even union by fibrous tissue; the fractured surfaces seemed worn, as if by rubbing upon one another. The clavicle seemed rotated downward and forward, following the fragment to which it was attached.

In the same Museum there is another fracture of the acromion, (No. 68,) presented by M. Cruveilhier. The one before mentioned had evidently belonged to a robust man; this seems to have been that of a woman. In other respects the two cases seem almost exactly similar; both fractures affect the right scapula; both have the same direction; both are of long standing, ununited, and have at their upper edges bony crests, especially marked upon the inner fragment. The one last named, however, has one peculiarity: while both fragments are on a level by their upper faces, the outer one is three or four millimètres below the other inferiorly; which has led the compiler of the *Musée Dupuytren* to think that *the two surfaces of the fracture had overlapped one another in their entire extent.* This was very important, as involving a displacement quite different from that observed in the other specimen. Now I have measured the fractured surfaces with the utmost care, and find, posteriorly, that

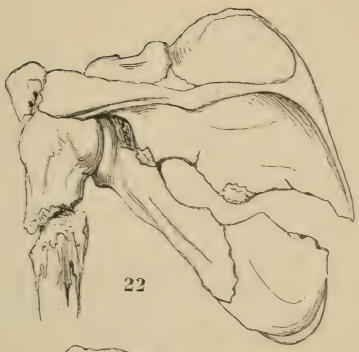
The scapular fragment is	7	millimètres in thickness.
The clavicular fragment is	12	" "

And in front, where the thickness is not yet lessened by the bevelling off at the outer edge of the acromion,

The scapular fragment is	5	millimètres in thickness.
The clavicular fragment is	9	" "

Hence there has been no overlapping of the surfaces; the two fragments, as has been stated, have remained on a level by their upper faces, and the extraordinary prominence of the clavicular fragment below is due to hypertrophy, by which its thickness has been nearly doubled,—a very curious phenomenon, sometimes met with elsewhere, especially in ununited fractures of the elbow.

PLATE IV.



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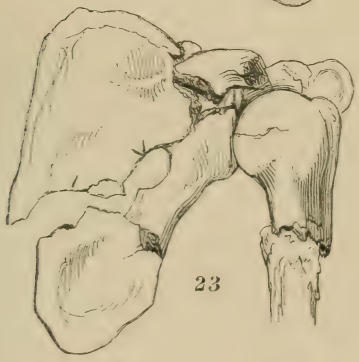

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PLATE V.

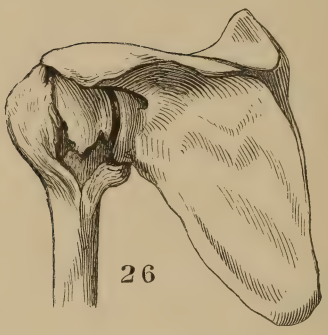

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PLATE V.

FIG. 26.—*Recent intra-capsular fracture.*—The left humerus is here seen, in its posterior aspect. The tuberosities, separated both from the shaft and from the head of the bone, are divided into three fragments and tilted outward. The head, detached at the anatomical neck, is partially crushed: the diaphysis, drawn up, is in contact with the lower part of the glenoid cavity. The capsule remained intact: it was divided in the preparation so as to display the fracture. See page 427.

FIG. 27.—An analogous specimen to the preceding. (*Museum at Val-de-Grâce.*)—The right humerus of an old woman, stripped of its soft parts, is seen by its anterior face. The head, separated from the diaphysis, is tilted outward; it has been detached also from the tuberosities, except a very small portion, which has remained adherent to them. The tuberosities are in their turn separated from the diaphysis, turned outward, and the greater one divided into two portions by a vertical fracture not shown in the drawing. See page 427.

FIGS. 28 and 29.—*Intra-capsular fracture, of long standing.* (*Museum at Val-de-Grâce.*)—In *Fig.* 28, the bone is seen by its anterior and inner face; in *Fig.* 29, it is turned around so that the head looks to the right.

Looking only at *Fig.* 28, the fracture would be thought to divide almost vertically the head and outer portion of the shaft, the outer fragment, comprising the two tuberosities, rising up a little above the other. The section shown in *Fig.* 29 will however correct the mistaken idea thus obtained. We can trace the walls of the diaphysis as far as the commencement of the epiphysis, proving the fracture at this point to have been transverse, and all the portion which seemed to constitute the outer fragment to be merely an exuberant callus. The two tuberosities, detached both from the diaphysis and from the inner part of the head of the bone, have been pushed outward, but not nearly so much as in *Figs.* 26 and 27; the head itself, displaced in the same direction, has lost some of its usual prominence; above may be seen a portion of its compact wall, which has penetrated the spongy texture of the outer fragment; at the lower and inner part, on the contrary, the fracture seems to have caused no other displacement than a slight flexion, while neither without (*Fig.* 28,) nor within, (*Fig.* 29,) do any traces of callus appear. These phenomena are common enough in epiphyseal separations: we shall notice them in the two following specimens, and also in a fracture at the lower extremity of the radius, *Fig.* 57.

FIG. 30.—*Extra-capsular fracture, with very slight displacement.*—I have given only a section of this bone. The displacement inward of the head of the bone may be seen by comparing its present with its normal outline, the latter being dotted out in the drawing; the callus at the inferior portion is quite voluminous, and when the specimen was entire gave it the appearance of a vertical fracture, as in *Fig.* 28. Externally, on the contrary, there is no trace of callus, the bone seeming to have merely bent at this point. The frequent occurrence of this phenomenon in epiphyseal disjunctions has been already alluded to. See page 419. (Read here, lines four and five from the bottom, *callus* instead of *neck*.)

PLATE VI.

Figs. 31 and 32.—*Fracture of the neck of the humerus, with more marked displacement.*—In *Figs.* 26, 27, 28 and 29, we have given the name of intra-capsular fractures to such as extended also beyond the limits of the capsule. Here the fracture penetrates somewhat beneath the capsule, as is seen by the irregularities of the head of the bone, (*Fig.* 31;) but this may be considered a mere epiphenomenon, the specimen having the essential characters of an extra-capsular fracture. See page 425.

In these two figures we see, especially by means of the dotted lines, how much the head and tuberosities have been inclined downward and inward. The inner wall of the diaphysis penetrates quite deeply into the spongy texture of the head; the outer wall, on the contrary, shows no line of demarcation, as if, as was remarked in regard t the preceding specimens, it had undergone a mere flexion.

The walls of the diaphysis are seen to be thinned, and the medullary canal to be filled up with spongy tissue. The man had been subjected to an amputation in the continuity of the humerus, a long time before his death.

Figs. 33 and 34.—*Fracture of the neck of the humerus, with complete disjunction of the fragments.*—See page 417.

Fig. 35.—*Double fracture of the shaft of the humerus.*—The upper fragment is displaced outward from the middle one, and this latter in front of the lower one. The callus is irregular and beset with roughnesses. See *Fig.* 26.

PLATE VI.

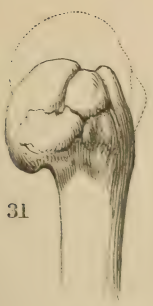

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PLATE VII.

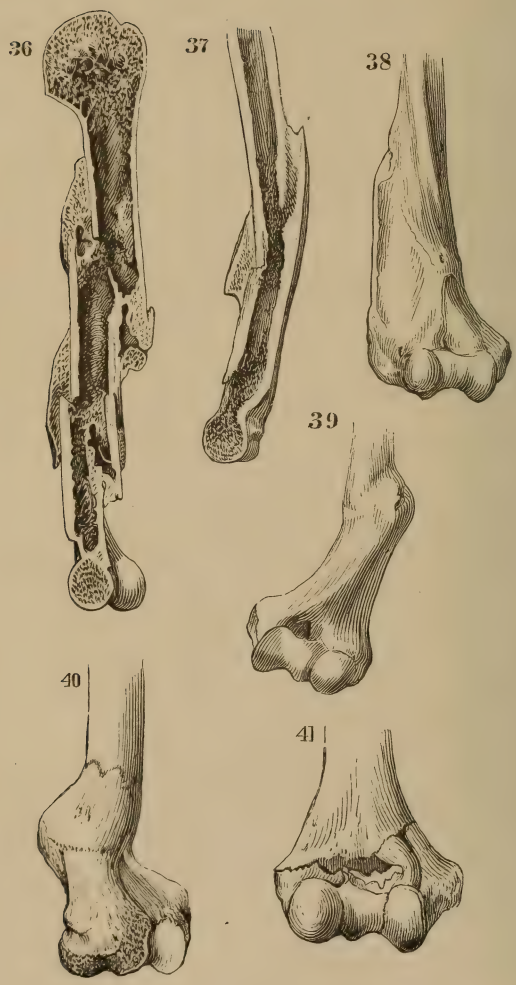


PLATE VII.

FIG. 36.—*Double fracture of the humerus.*—This is the same bone as that represented in *Fig.* 35, seen in section. The callus is seen to be exuberant, and spongy throughout: besides which, the fragments of the shaft are channeled by abnormal sinuses, attesting the fact of an inflammation of their tissue. This fact serves to explain the irregularity and abundance of the callus.

FIG. 37.—*Single fracture, with separation of a splinter from the anterior face of the bone.*—The lower fragment is carried backward, forming with the other an angle salient posteriorly. The callus is spongy; in spite of the contact of the two fragments in front, the compact tissue remains ununited.

FIG. 38.—*Fracture running obliquely downward and outward: displacement in the same direction.* (*Musée Dupuytren*, No. 86.)—This specimen was presented by Professor Lassus.—The direction of the fracture is so evident in the specimen, that it needs no comment. The upper fragment is carried forward and inward, the lower outward and backward: I may add that the two fragments, in contact below, are so separated above as to form a very acute angle opening upward, filled up by callus, but betrayed by a wide vertical groove.

The humerus, thus consolidated, is thirty-three centimètres in length; the end of the upper fragment has descended to within eight centimètres of the elbow-joint, that of the lower has ridden up twelve centimètres away from it.

FIG. 39.—*Fracture running downward, inward, and a little forward.* (*Musée Dupuytren*, No. 87.)—The line of division begins six centimètres above the joint; in consequence of its course, the lower fragment has ridden up outward and forward, making with the upper one an angle salient in both these directions, so that the former fragment projects strongly in front of the inner face of the latter.

FIG. 40.—*Fracture running obliquely downward and backward.* (*Musée Dupuytren*, No. 83.)—Presented by Professor Lassus.—The bone is so represented as to show its outer face, with a part also of its posterior face, and especially the great sigmoid cavity. This being understood, it may be seen at once that the lower fragment has ridden up in front of the other, as might have been expected from the direction of the fracture downward and backward: and that it forms a very marked prominence anteriorly, so that its posterior face, which in the normal state is curved a little forward, is here very strongly turned backward. The angle thus formed may be estimated at 135°, and during life there must have been some of the appearances of luxation backward.

FIG. 41.—*Fracture above and between the condyles.*—This specimen I received from M. Huguier. The fracture above the condyles runs downward and backward; hence the upper fragment has descended behind the lower as far as to the tip of the olecranon.—a displacement not shown in the cut, in order to give the other points more completely. *See* page 446.

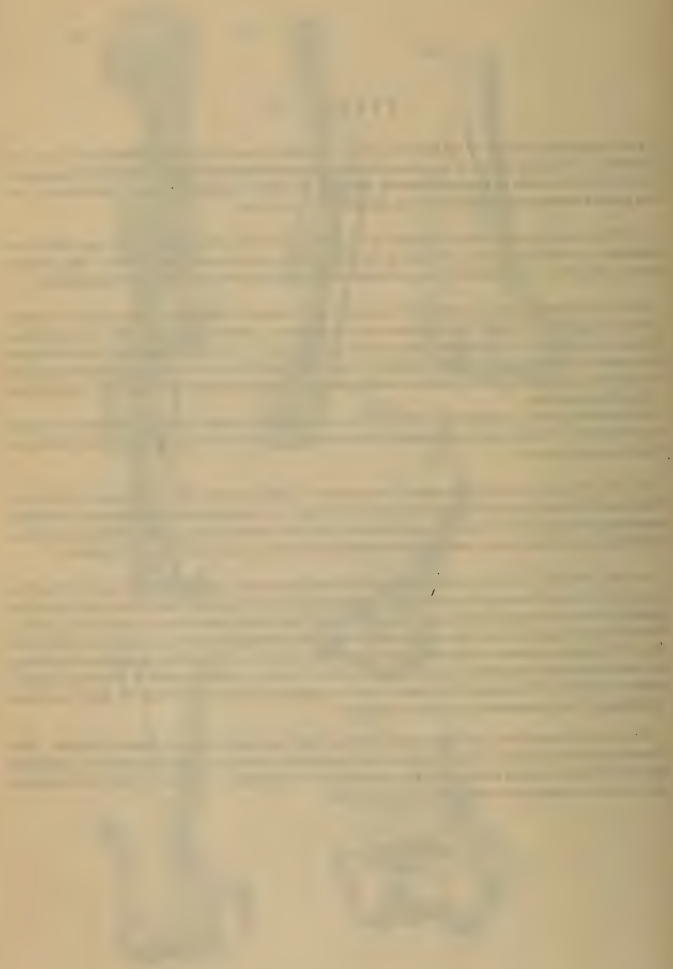


PLATE VIII.

FIGS. 42, 43 and 44.—*Fracture of the outer condyle of the humerus, through the middle of the trochlea.* —I found this remarkable lesion in the body of a man forty years of age, who had sustained it in infancy, and in whom the forearm had enjoyed nearly all of its functions.

In *Figs.* 42 and 44 the oblique line of the fracture is very distinctly seen, running up apparently about two and a half inches along the outer edge of the bone. Nevertheless, the greatest diameter of the detached portion does not exceed an inch and a half; so that we must presume either that the original surface of fracture of the diaphysis has been increased by abrasion, or that the fragment itself had its apex broken off; in *Fig.* 44, indeed, there may be observed some small rounded bits of bone, which may be considered as splinters somewhat altered in shape. There is no trace of union between the fragments—not even by fibrous tissue; but they must have rubbed against one another in the movements of the forearm upon the arm, causing a sort of wearing away, which has very certainly diminished the transverse diameter of the detached piece; no trace of the outer half of the trochlea is perceptible in this fragment, which seems to have reacted upon the diaphysis in the same way. The fractured surfaces are clean, almost smooth, eburnated; and the resulting false-joint was supported only by the external ligaments. *Fig.* 44, in which the fragments are separated, shows the posterior ligaments.

Besides this wasting, the effects of which are perceptible even upon the sigmoid cavity of the ulna, there presents itself another, in a manner entirely opposed to it; this is the hypertrophy of the head of the radius, of the condyle of the humerus corresponding to it, of the upper extremity of the ulna, (the olecranon is four centimètres wide posteriorly,) and even of the remaining portion of the trochlea.

The position of the forearm in the dead subject was intermediate between flexion and extension, as may be seen in *Fig.* 42. The outer fragment is carried up above the level of the other fractured surface; the condyle is much above its normal place with relation to the trochlea; the forearm was in consequence not only flexed forward, but inclined and as it were bent outward.

Flexion could be carried beyond a right angle, (see *Fig.* 43,) but then it took place principally outward, the ulna abandoning the trochlea to apply itself to the lower part of the fractured surface, and the radius riding up so as to make the outer fragment overlap the diaphysis.

Extension was difficult, and incomplete, (see *Fig.* 44;) the ulna then returned to the trochlea, the radius, with the humeral condyle, descended again, nearly to its normal level; but the fragments remained separated by an interval which attested the wasting they had undergone, and which would have been wider had the extension been increased; this extension was hindered, on the one hand by the hypertrophy of the olecranon, on the other by the tension of the ligaments seen in the figure.

In this position of the fragments it is plain that the smaller one would, but for the loss of substance by wear, have projected much more considerably outward than in the normal state; which accords with the enlargement of the articular surface of the condyle. But at the same time the tip of the smaller fragment is drawn forward by the muscles arising from it; a displacement not uncommon in these fractures.

The humero-radial articulation has not suffered, as is seen by the excision of a portion of the capsular ligament. (*Figs.* 42 and 44.) The radio-ulnar articulation was also sound, and the movements of pronation and supination well maintained.

FIG. 45.—*Comminuted fracture of the elbow.* (*Musée Dupuytren*, No. 90.)—Specimen presented by M. Callé.—This fracture was of twenty-seven years' standing, and in spite of the excessive crushing of the articular extremities, the elbow retained nearly all its motions. See page 468.

PLATE VIII.

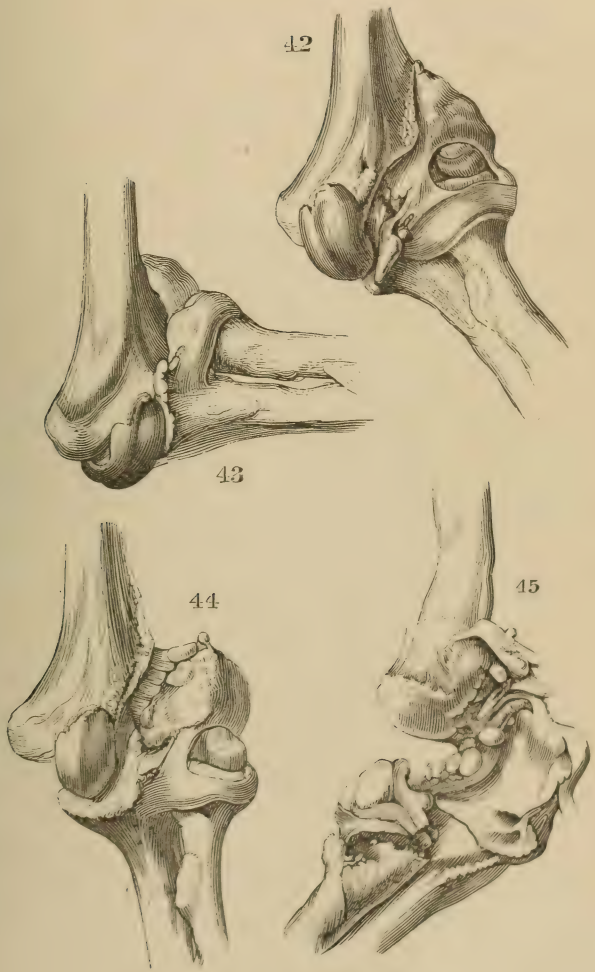


PLATE IX.

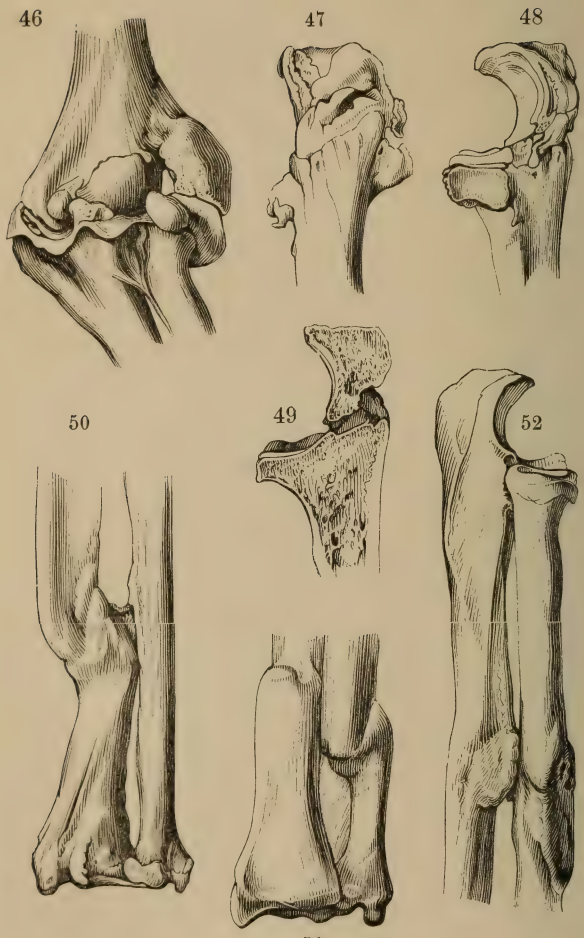


PLATE IX.

FIG. 46.—*Fracture of the external condyle of the humerus, with incomplete luxation inward of the ulna.* —I found this specimen in a dead subject, and as is almost always the way in such cases, without previous history. I have had it drawn as an instance of fracture limited to the condyle: but there is present also a luxation, which calls for separate study.

In spite of the distortion of the joint, it is easy to prove that the trochlea is unaffected. The fracture is seen in the figure to be outside of a line which would be the continuation of the anterior edge of the humerus; and in the specimen the fracture is found at its posterior aspect to skirt the outer border of the cavity for the olecranon, which is hardly touched. The outer fragment remains separated from the other, nor are the two brought in contact by any motion: the interval is filled up by cellular tissue and a prolongation of the synovial membrane; above, only, there is a fibrous callus investing both fragments to quite a considerable extent. The articular surface of the condyle has disappeared; the head of the radius is distorted, answering to the outer fragment only by a facette formed upon its outer edge, a similar facette being established upon the fragment.

But the accompanying luxation is of still greater interest: the ulna is seen in the figure to be thrown inward, so that the inner edge of the olecranon is on a level with the deformed epitrochlea; the tip of the coronoid process answers to a new groove at the inner side of the trochlea: this latter, instead of its normal shape, presents merely a rounded prominence, just below the anterior edge of the diaphysis, *i.e.*, just where the narrowed part of the trochlea should be. The lesser cavity of the humerus is wanting: the greater is almost entirely preserved. On the whole, the luxation is a direct one inward of the ulna, without any apparent fracture of the trochlea; the head of the radius seeming to have been separated from the lesser sigmoid cavity of the ulna at the outset. This luxation is evidently of very ancient date, and time has effected some changes in it.

In the first place, the inner facette of the sigmoid cavity, rubbing against the posterior surface of the epitrochlea, has induced the formation upon it of a convex articular face, covered with cartilage. The outer one, coming against the abrupt edge of the trochlea, has pushed it backward, forming upon it another articular face, likewise invested with cartilage. Between the two is a sort of pulley-groove, covered with synovial membrane and fibrous tissue.

This turning outward of the inner border of the trochlea could not occur without pushing out the head of the radius, which bore against it by its concave end, and widening the space between the latter bone and the ulna. The head of the radius, therefore, presses partly against the outer edge of the trochlea, and partly answers to the interval between the fragments. Hence, it has compressed and pushed inward the inner edge of the trochlea, so as to obliterate the groove, and to wear away the trochlea itself, making it present a vertical facette. But the *point d'appui* of the trochlea being absent, it has developed itself into the space above it so as to be nearly a centimètre above its usual level. Moreover, in order to lengthen in this abnormal direction, the radius has bent outward at its neck, as is distinctly seen in the figure.

Besides this, the head of the radius is hypertrophied from side to side, as is also the ulna.

In front of the head of the radius is seen an oblong bit of bone, and another above the coronoid process of the ulna; these would seem to me less likely to be splinters, than deposits of bone, such as are observed in the vicinity of old luxations.

Lastly, the habitual posture of the forearm was that of semi-flexion, and its motions were very limited, either toward extension or more complete flexion.

FIGS. 47, 48 and 49.—*Fracture of the olecranon.* (*Musée Dupuytren*, No. 104.)—Specimen presented by M. Bordet. —— Mulsant, a man aged 86, was admitted into the Infirmary at Bicêtre, in November, 1836, and died of double pleurisy on the same day, having given no history of himself. At the autopsy there was found a luxation of the left humerus, and a fracture of the left elbow: M. Bordet then traced the man's story, until he learned that the luxation had been caused four years previously, by a fall on the ice. The patient had not submitted to any treatment. M. Bordet supposed that the fracture of the elbow was the result of the same accident; but this could not be positively ascertained. However that may have been, let us study the specimen.

The olecranon has been detached by a fracture which posteriorly is quite oblique, running downward and outward, but which is much more oblique and more irregular anteriorly. On the outer side the fracture has separated quite accurately the anterior and posterior facettes of the sigmoid cavity; but at the inner side it passes up over the olecranon, leaving a portion of the inner edge of the latter attached to the coronoid process. Near the same point, a small irregular fragment has been broken off from the olecranon, and is held to it only by fibrous tissue; and lastly, it may be said that another little bit has been detached from the articular surface and driven backward, where it has adhered to the lower fragment.

Besides this obliquity from within outward and from above downward, there is another downward and forward, the level of the fracture being perceptibly higher at the posterior face of the olecranon.

M. Bordet thought that he saw also a fracture at the inner edge of the coronoid process, united by bone; and the deformity at this part of the process might favor such an idea, as well as the existence of perceptible fissures in the articular cartilage, and the depression of the apex of the process. I have, however, sought in vain for any positive traces of such a fracture, and the deformity seems to me to result from an entirely different cause.

It seems to me to be evident, also, that the fracture of the olecranon has been produced by crushing, and not by muscular action. There are, however, one or two remarks to be made.

(1.) The base of the process is manifestly carried inward several millimètres from its usual position; and as an inevitable consequence of this displacement, the small fragment of this, and that of the supposed fracture of the coronoid process, are notably borne inward also.

(2.) On the contrary, the apex of the olecranon is plainly thrown outward, being in the same vertical line with the sigmoid cavity of the ulna.

(3.) Lastly, the apex of the olecranon is inclined downward and forward more than usual, whence it results that the separation of the fractured surfaces is much more considerable posteriorly than anteriorly.

Thus the separation posteriorly is more than one centimètre. Union has been accomplished here by means of two thick lateral masses of fibrous tissue, leaving a gap between them. In front there is no trace of union for a distance of three or four millimètres and more from the articular surface; and especially in the inner half, the fibrous tissue is almost confined to the posterior surface of the bone, without penetrating, so to speak, between the fragments.

From the inclination forward of the apex of the olecranon has resulted a flattening of that of the coronoid process, explained better in this way than by a separation of which I see no sufficient evidence; but whatever was its cause, this alteration of the sigmoid cavity must have notably interfered with extension of the forearm.

The coronoid fragment, carried inward, plays upon the inner edge of the trochlea. The radius showed no change either in its form or relations, except, perhaps, that a small bony growth existed near the posterior limit of the radial facette of the ulna.

FIG. 50.—*Fracture of the left radius in its lower third.* (*Musée Dupuytren*, No. 100.)—Specimen presented by Professor Breschet.—The forearm is seen from behind; the position of the articular surface of the radius indicates complete pronation. The fracture may be traced, through the very firm callus, running somewhat obliquely downward and outward, so that the overlapping might have been expected to carry, as it has done, the lower fragment inward, the upper one remaining in place, or even deviating somewhat outward. Hence the narrowing of the intercostal space below, while above it is, to say the least, maintained. The overlapping, moreover, has not done everything; it was limited by the inferior radio-ulnar ligaments, so that the inner portion of the articular face of the radius has kept its place: but the styloid process is so raised up that the ulna, if the two bones were rested upon the two styloid processes, would incline somewhat outward, instead of inward, as in the normal state of things. It is, then, mainly this riding up of the radial styloid process which has tilted the lower fragment inward, a movement limited only by the ulna, against which this fragment rests, and to which it is connected by fibrous tissue. It is also carried a little forward, while the upper one points backward. Lastly, it may be remarked that this latter is rounded off at its broken end, more than the original shape of the bone can explain; this is due to absorption of the bony texture from the pressure of the skin and aponeurosis, and attests the age of the fracture.

FIG. 51.—*Fracture of both bones of the forearm, with displacement of all four fragments.*—The fracture of the radius is seated at the junction of the lower with the middle third of the bone: that of the ulna in its lower fourth. The lower fragment of the ulna has passed up backward, that of the radius forward, involving a very marked displacement by rotation: the lower portion of the forearm being almost pronated, while the superior remains nearly supinated. The result of this rotation has been that the lower fragment of the radius, carried in front of the upper fragment of the ulna, is separated by it from the lower fragment of the ulna, so as to preserve the interosseous space almost entire below, while higher up it is considerably narrowed by the approximation of the superior fragments. See pages 472 and 473. (On page 473, line six, for "52" read "51.")

FIG. 52.—*Fracture of both bones of the forearm at about their middle.*—See page 472

PLATE X.

Fig. 53.—*Fracture of both bones of the forearm at the same level, five centimètres from the wrist, with luxation inward of the ulna.*—This specimen was taken from a woman aged 25, without previous history. Both fragments of the radius are inclined inward toward the ulna. The lower radial fragment has also ridden up upon the other, as well as upon the ulna; hence the change of level of the articular face of the radius, and a luxation of the ulna inward. See pages 474 and 483.

Figs. 54, 55 and 56.—*Recent fracture of the lower extremity of the right radius, and of the styloid process of the ulna.*—Specimen presented by M. Maisonneuve.—The fracture was at the fourteenth day; but the pneumonia which carried the patient off had hindered the work of repair. *Fig.* 54 shows the anterior aspect of the bones, *Fig.* 55 the posterior; *Fig.* 56 shows the transverse direction of the fracture, interrupted however by numerous serrations. See also page 487.

Fig. 57.—*Fracture of the lower extremity of the right radius, in process of consolidation with deformity.*—This specimen was taken from a woman who died about four weeks after her accident; but the malady which carried her off had retarded the formation of the callus, and the bone having been subjected to maceration, an important part of the callus disappeared.

The radius is seen from one side; the anterior faces of the two fragments have remained in nearly the same vertical plane, but the lower piece is a good deal tilted backward. Thus the anterior edge of the articulating surface is no longer prominent; the styloid process is raised to the same level with it, and the posterior edge is still higher yet. The upper fragment seems to bury itself posteriorly in the spongy texture of the lower one, and the angle here formed was previous to the maceration entirely filled up by a deposit of callus. Of this there remain only a few slight traces, two or three centimètres farther up on the upper fragment; but in *Fig.* 59, taken from an older fracture, the callus is seen passing obliquely up along the diaphysis, and filling an angle at least as wide as that in *Fig.* 57. See pages 489 and 490.

Figs. 58 and 59.—*Old fracture of the lower extremity of the radius, with vicious consolidation.*—In *Fig.* 58 the bones are seen by their posterior faces; but nearly the whole articular surface of the radius appears, showing how much its posterior edge is carried above the level of the anterior. This is still more evident in *Fig.* 59, where the degree of elevation is seen to be thirteen millimètres; the anterior face flattened, the posterior making an abnormal prominence, and the posterior wall of the diaphysis buried in the spongy texture. But this spongy texture hardly belongs to the original bone; the greater part of it is formed of callus, which has filled up the angle between the upper and lower fragments. *Fig.* 58 shows also the styloid process of the radius on a level with that of the ulna, or even a little above it; and as the interosseous space is not lessened, it is clear that the carrying up of this process depends on the tilting backward of the lower fragment, and not on its inclination toward the ulna. See page 489.

Fig. 60.—*Fracture of the second metacarpal bone, with overlapping and inclination forward of the lower fragment.* (*Musée Dupuytren*, No. 110.)—The bone is seen at its inner face, *i.e.* the one turned toward the third metacarpal. The fracture seems to have been oblique downward and forward; the lower fragment, overlapping the other, makes a very marked projection at the back of the hand, while its head is inclined toward the palm. Besides this angle, which is well shown in the figure, there is another less perceptible one, in virtue of which the lower fragment is carried to the outer side of the superior, and its head turned very much inward. There must have been during life shortening of the index finger, an inclination of this finger toward the palm of the hand, and at the same time toward the third metacarpal, and lastly a prominence at the back of the hand, toward the thumb.

Fig. 61.—*Very oblique fracture of the second metacarpal bone, united with hardly any perceptible displacement.*

PLATE X.

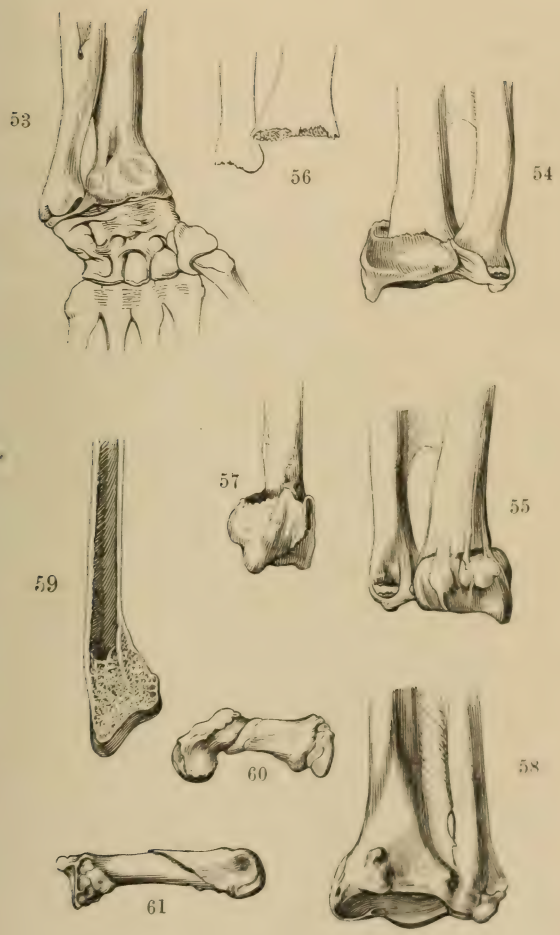
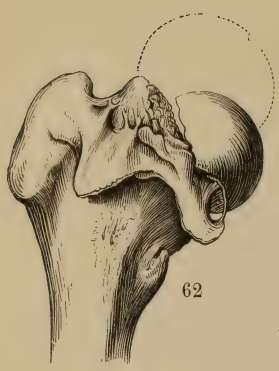


PLATE XI.



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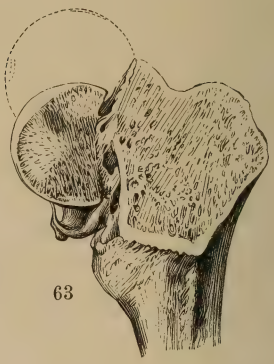

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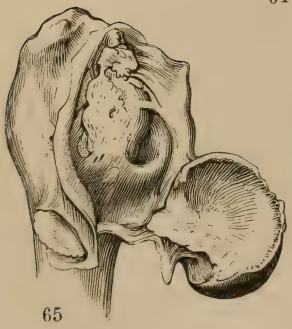

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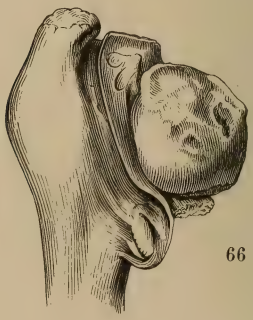

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PLATE XI.

Figs. 62, 63 and 64.—*Fracture of the cervix femoris, dating back six months and a half: intra-capsular above, extra-capsular below.*—Eustache, aged 76, fell directly upon the great trochanter, May 20, 1841. I detected a fracture of the neck of the bone, probably intra-capsular, and put the limb on a double inclined plane. About the 16th of July, I tried to make him get up; but acute pains in the hip prevented his doing so. Toward the end of August he could walk with crutches; but the pains coming on again, he took to his bed, where he remained until he died, on the 7th of December.

The foot was very little everted; the trochanter was more prominent than that of the sound side, and described a large arc when the limb was rotated; the rotation seemed to take place in the joint, so that I doubted whether the fracture were not extra-capsular. But upon dissection the state of things was found to be as shown in *Fig.* 62; only that the synovial membrane lining the capsular ligament was adherent to that covering the neck, at the seat of the fracture, and that nearly all the cartilage of the head, and the round ligament, seemed wanting; it was almost entirely blended with the pad of fat, forming with it a uniform reddish mass; and the head of the bone, thus fixed to the bottom of the cotyloid cavity, did not share in any movement of the limb.

The head of the femur, situated below the level of the trochanter, has been detached from the neck by a fracture running downward and inward, commencing above just at the junction of the cartilage of incrustation with the synovial membrane, and terminating below about two centimètres to the outer side of the cartilage, consequently outside of the capsule. The trochanter, with the shaft of the bone, is carried upward and somewhat forward, and the head of the bone has descended so as to rest against the inter-trochanteric line, a little above the lesser trochanter. (*Fig.* 63.) The upper edge of the cervical fragment is therefore notably above the level of the head; it has remained separate from it, and the fractured surface at this point is covered with a smooth white cartilage. Lower down, there is still an interspace of one or two millimètres between the fragments; the cervical surface is covered with red granulations, which do not appear upon the other; and lastly, union by fibro-cartilaginous tissue has commenced at several points. (*Fig.* 63.) In this same figure an attempt has been made to show a very curious point. Entirely outside, the spongy texture of the trochanter has its ordinary yellow tinge; but close to the fracture and in three-quarters of its thickness, it is of a deep red color. So also in the head of the femur, the spongy tissue of the upper fourth, where the separation is complete, is yellow and hard, as if necrosed; the remainder of it is red, as is seen even through the incrusting cartilage.

Figs. 65 and 66.—*Intra-capsular fracture of nine months' standing: no trace of union.*— Louis Marie, aged 73, was thrown upon his buttocks by some one pulling away a chair in which he was about to sit down; he was able to rise and go to his room, and could walk the next day; the day after, July 22, 1840, he came to the infirmary. At the end of five months he went out; he limped a little in walking, was easily fatigued, and could not stand long at a time. He died April 24, 1841.

The foot was not more everted than the other; but it could not be turned inward, being arrested in the vertical position. The shortening was at most about one inch. The thigh could be completely extended upon the pelvis, and flexed to an angle of more than 45°; adduction was as easy as in the sound limb, but abduction was almost impossible.

The capsule was infiltrated bright red in the vicinity of the cotyloid cavity; the round ligament and the fatty pad presented the same tint. The fracture was entirely intra-capsular, and the head of the bone connected with the capsule only by adhesions. (*Fig.* 65.) it may be seen in the same figure that no union of any kind has taken place between the fractured surfaces. The head, much diminished in thickness, seems worn away at the side next the fracture, where it presents no trace of any process of repair. But upon its articulating surface are seen irregular deposits of bone. (*Fig.* 66.) indicating a kind of hypertrophy. The fractured surface of the cervix would seem at first to have been likewise worn away, and presents no prominence; but, on measuring the thickness of the bone at this part, it is found to be rather increased, by the addition of thick, glistening, eburnated plates of bone.

In these two drawings we see a curious transformation of the lesser trochanter into an eburnated facette, covered with a synovial bursa, but separate from the articular cavity. In flexion, the head descended to this point, and the bursa was probably the result of friction.

What is particularly striking in this case is the recent date of the fracture. Are such changes in bone possible in so short a time, or did the patient's memory deceive him?

PLATE XII.

FIG. 67.—*Old intra-capsular fracture, with considerable shortening.*—I found this fracture in the body of an old man, whose previous history was unknown. The body rested naturally upon the left side, and in fact could not remain upon the back; for the right lower extremity, in which was the fracture, was adducted and rotated inward, so that the axis of the trunk fell an inch to the outer side of the right knee, and the right foot rested on the table by its inner edge.

The fracture seemed to be seated just at the junction of the head and neck of the bone; the head was unconnected with the capsule, but adhered to the cotyloid cavity by reddish false membranes, which had taken the place of the cartilage at various points. The fractured surfaces were united only by some fibrous and membraniform bands, of considerable length. The head seemed to have lost thickness: the other fragment showed no very marked trace of the cervix, but its thickness was not apparently diminished.

The femur being drawn up, and at the same time adducted, the head is depressed upon the lower part of the cervix, even down to the lesser trochanter, where an articular facette has been formed; part of the psoas tendon is transformed into a movable *osseo-fibrous* plate, as if to complete this facette. The capsule seems to have been worn away below, and to have been replaced by a thin, soft, cellular membrane, extending from the edge of the cotyloid cavity to below the lesser trochanter. Above, on the contrary, the capsule, although stretched, is quite thick, and even contains cartilaginous nodules here and there; it was owing to this tissue that the femur did not ride up more. The shortening amounted, however, to nearly two inches, not including that due to the adduction of the limb.

It should be added that the head was not in contact with the cervix at all parts of its fractured surface. The points of attachment of the fibrous bands were just those where there was no contact; all the parts subjected to friction were eburnated.

FIGS. 68 and 69.—*Ununited extra-capsular fracture, with division of the base of the great trochanter.*—Messager, a decrepit old man, eighty-seven years of age, sustained this fracture by falling from his chair upon his right hip, June 2, 1841. I put him upon a double inclined plane until July 10; after which he kept his bed, from debility; drinking freely, but eating little, and sleeping constantly. He remained thus until the latter part of August, when scorbutic symptoms appeared; soon after this, a slough formed over the sacrum, and on September 4 he died.

The fracture, although of three months' standing, showed no sign of consolidation having begun. I have had it drawn with the fragments in their proper positions; the fracture is seen to be entirely outside of the capsule; the greater trochanter is detached at its base, the fragments not corresponding exactly, partly from the edge of the lower fragment being worn away, and partly by the loss of a number of little splinters. Nearly all the spongy tissue within the neck has been crushed up, except two pieces seen in *Fig.* 69.

In the body, the lower portion of the part of the neck attached to the head was buried in the shaft, exactly as is seen in *Figs.* 70 and 71; the head was very much inclined downward, and the trochanter depressed inward and backward, lying, as it were, upon the summit of the shaft. It was friction upon the cervix which had worn and polished the edge of the lower fragment, and it was this edge which, preventing the cervix from descending farther, had limited the shortening.

The fragments being entirely unconnected, I tried the effect of extension in this subject. My experiments are detailed at page 566; but a glance at this and the two following drawings will show clearly that traction in a straight line, made upon the head and shaft of the bone, could never bring the fragments into their proper relations.

FIG. 70.—*Extra-capsular fracture, united, with fracture of the greater trochanter.*—I have given in my memoir *Sur quelques dangers du traitement ordinaire des fractures du col du fémur*, the clinical history of this case. I may say here that the patient, whose name was Lambert, was coachman to M. Roux, and was treated at La Charité by Boyer, and by M. Roux himself. In spite of powerful continued extension, which lacerated his groin and ankle, and induced mental disorder, he retained a shortening of three and a half centimètres. He died at Bicêtre, at seventy years of age, about sixteen years after his injury.

In the figure, the lower part of the cervix is seen so driven into the diaphysis, that the head of the bone is almost in contact with the inner wall of the latter; and it is easy to see, from the contact of the compact wall of the diaphysis with the spongy texture of the cervix, that the length of the limb has not been increased a single millimètre by the continued extension. A line of compact bone reaches from the point of junction up into the centre of the head itself; this is merely an adventitious formation.

Another fracture had separated the anterior and superior portion of the greater trochanter. To judge of the degree to which the tip of this epiphysis has been driven inward, we need only compare with this *Figs.* 62 and 68, in which the trochanter is represented in its normal state.

FIG. 71.—*Consolidated intra-capsular fracture, with fracture of both trochanters.*—I do not know the history of this specimen, which belongs in my own collection; on the one hand, the head of the femur is seen to be hypertrophied, and its edge folded over on the cervix, like a mushroom, indicating senile disease of the hip-joint; on the other, the lower wall of the cervix is so driven in as nearly to reach the outer wall of the diaphysis. So far, the appearances are almost the same as those in the preceding figure; but here both walls of the diaphysis are evidently fractured at the same level, and in the specimen the two trochanters were seen to be separated together from the rest of the bone; so that the cervix has descended much lower, and the shortening must have amounted to five or six centimètres. Here, as in the preceding figure, the tilting inward of the tip of the greater trochanter should be observed.

PLATE XII.

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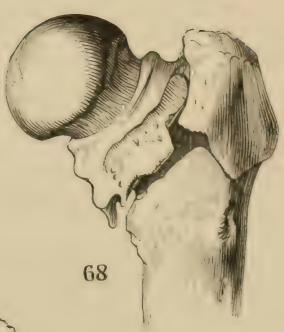

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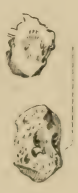

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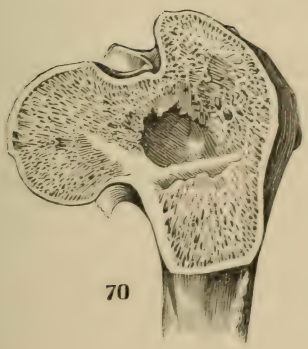

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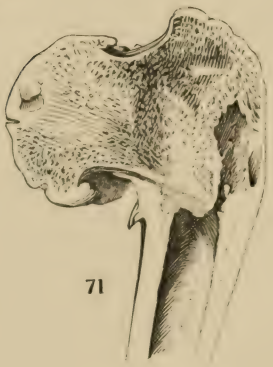

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PLATE XIII.

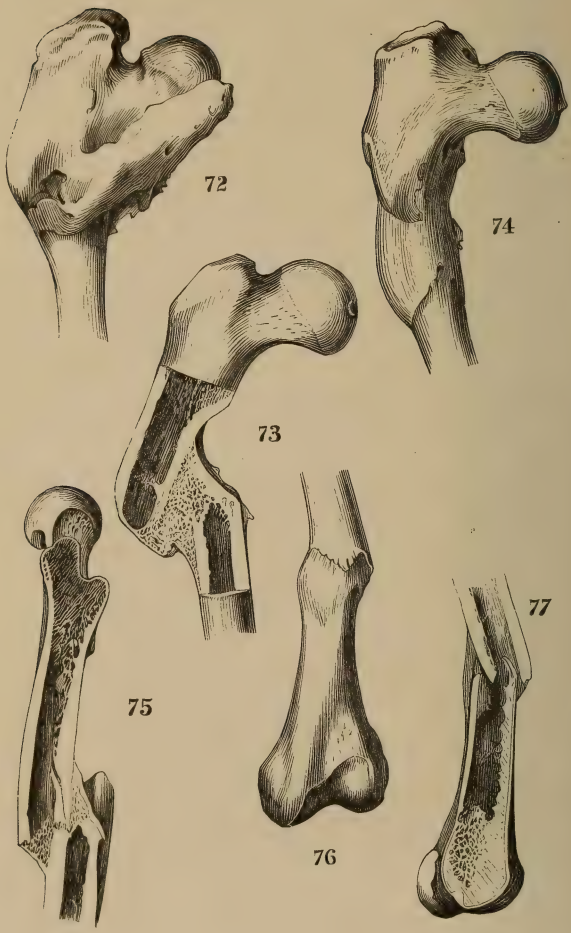

PLATE XIII.

FIG. 72.—*Fracture just below the trochanters, with deformed callus.* (*Museum at Val-de-Grâce.*)—The femur is seen in front. The fracture seems to have been seated just below the trochanters; the lower fragment has been drawn up behind the upper, which is strongly abducted, so that the head of the bone is inclined very much inward and forward. An enormous callus envelops both fragments posteriorly, and a very large stalactite is seen coming forward under the head and neck of the bone, as if to support them.

It is remarkable that the upper fragment, although in front of the other, has not been flexed in the slightest degree; on the contrary, it may be said to be pushed backward toward the lower fragment.

This lower fragment is thirty-four centimètres in length, from the inner condyle; the upper, about eight centimètres, measuring from the seat of fracture to the tip of the greater trochanter—in all, 42 centimètres; and the head of the bone being one or two centimètres above the level of the greater trochanter, the entire length of the sound bone must have been 43 or 44 centimètres. Now in its present condition the femur, measured from the inner condyle to the tip of the greater trochanter, is only 39 centimètres in length, showing the shortening due to the overlapping to be about three centimètres; and from the inner condyle to the summit of the head of the bone, the distance is but thirty-seven and a half centimètres, showing a shortening of two and a half to three centimètres due to the inclination of the latter.

FIG. 73.—*Fracture six centimètres below the lesser trochanter.* (*Museum at Val-de-Grâce.*)—The femur is seen in front. The upper fragment is strongly tilted outward; it does not project forward more than one centimètre. The section made opposite the callus shows sufficiently the relations of the two fragments: the actual overlapping does not exceed one centimètre.

Now the length of the lower fragment, measured from the inner condyle, is 28 centimètres; that of the upper fragment, from the tip of the greater trochanter, is 14 centimètres—in all, 42 centimètres. In its present condition, the bone measures only 40 centimètres from the trochanter to the condyle, and at most 39 centimètres from the condyle to the top of the head of the bone. The entire displacement amounts, therefore, to three or four centimètres, only one of which is due to overlapping, and the rest to angular displacement.

FIG. 74.—*Double fracture in the upper third of the diaphysis.* (*Museum at Val-de-Grâce.*)—The femur is seen in front. The upper fragment is carried strongly outward, hardly at all forward; the middle one is behind the upper, and outside and in front of the lower one. Upon superficial examination, such a result might be wondered at; and even upon measurement, the lower fragment is twenty-nine, the middle six, and the upper one eight centimètres in length; (the fractures being very oblique, the tips of the fragments are measured from.) The femur should therefore measure from the greater trochanter to the inner condyle 43 centimètres, and does actually measure 40; but its length from the condyle to the tip of its head, which should be 44 or 45 centimètres, is reduced to 38: an excessive shortening, due in great part certainly to angular displacement.

FIG. 75.—*Oblique fracture at the middle of the femur.* (*Museum at Val-de-Grâce.*)—The femur is seen from one side: it has been sawed open antero-posteriorly; in the figure it is seen that the posterior wall of the shaft has been separated a little higher up than the anterior, but the tip of the lower fragment is plainly seen drawn very much up behind the other. The overlapping has been arrested here by the two fragments coming in contact; the posterior wall of the shaft in the upper one bearing against the anterior wall in the other. They formed also an angle salient outwardly, which could not be shown in the figure.

FIGS. 76 and 77.—*Fracture in the middle third of the femur, with wide serrations mutually interlocked.* (*Musée des Hôpitaux.*)—The callus is not yet ossified, but has sufficient firmness to keep the two fragments apart. The upper fragment is indeed carried somewhat outward (*Fig.* 76) and forward, (*Fig.* 77;) but still it presents two large serrations, which, by interlocking with corresponding indentations in the lower fragment, obviate any overlapping.

PLATE XIV.

Fig. 78.—*Fracture just above the condyles of the femur.* (*Musée Dupuytren*, No. 150.)—This fracture runs obliquely downward, outward, and somewhat forward; the upper fragment, displaced in this triple manner, has pushed the patella downward as far as the tibia, so as really to luxate it downward. The other fragment has remained parallel with this one.

Figs. 79 and 80.—*Transverse fracture of the patella, united by bone.*—I found this specimen in the body of a man who had on the left side the much graver lesion represented in *Fig.* 84. The first was not suspected during life. In *Fig.* 79 there is seen a solution of continuity of the cartilage, involving its whole width and thickness; at each end, for a distance of one or two millimètres, union seems to have occurred in the middle there is nothing of the kind. At its anterior face (*Fig.* 80) the bone presents a transverse groove of slight depth, about five millimètres in width, filled up at its inner extremity, and denoting a separation made good by bony deposit.

Fig. 81.—*Transverse fracture of the patella, united by fibrous tissue.*—This specimen was taken from an old man at Bicêtre, who two years before his death had broken the patella by a fall, his knee striking a step. The separation in the dead body was three fingers'-breadths; it was therefore much increased upon dissection. The ligamentum patellæ, greatly thickened, was but three centimètres long at its posterior face; in the other limb it was six.

I have mentioned (page 609) the constituents of the fibrous tissue uniting the fragments, and also (page 610) the curious tilting of the lower fragment, so that its posterior face looks directly upward. Both fragments were in a state of evident hypertrophy.

Fig. 82.—*Transverse fracture of the patella, united by fibrous tissue.* (*Musée Dupuytren*, No. 202.)—This figure is intended to show the inclination forward of the lower fragment; the fractured surface presents a plane inclined forward and downward, which would lead one to suppose, but for the light given by the preceding figure, that the fracture had separated the bone in this direction. In the specimen this inclination was clearly due to the tilting of the fragment, since the point of the lower fragment was carried backward.

The upper fragment itself seemed to be inclined backward by its upper end, as if the fracture had been treated by double pressure. Lastly, upon its anterior surface were deposits of new bone, giving it a thickness of two and a half centimètres.

Fig. 83.—*Comminuted fracture of the patella, united by fibrous tissue.*

Fig. 84.—*Fracture of the patella united by fibrous tissue, recurring twice, and at last followed by death.*—Denton, aged 61, had had several years previously a transverse fracture of the left patella, united by fibrous tissue, which had been ruptured and reunited; he slipped and fell backward on the 7th of February, 1839, when the callus gave way for the second time. But at the same time the skin over the knee was greatly ecchymosed; a slough formed, laying open the articulation, and on the 2d of March he died.

The fragments were separated to an extent of five or six centimètres, with hardly any traces of the fibrous callus. Their articulating surface is seen in the figure. The upper one is deformed; a crescentic zone, covered with periosteum, occupies its upper part for a width of eight to fifteen millimètres; the portion which is still covered with cartilage is limited above by this zone, below by a prominent bony ridge running the whole length of the fracture. The lower fragment is almost entirely stripped of cartilage, and corroded by suppuration. It would seem to comprise two portions; one, representing its original form, is two and a half centimètres in vertical diameter; the other, situated above this one, is a bony prolongation two and a half centimètres in width by one in vertical diameter, which would seem sent up toward the upper fragment; and as the vertical diameter of the latter is three centimètres, the bone has acquired a vertical diameter of six and a half centimètres, while the other patella of the same subject (*Figs.* 79 and 80) measures at most only four and a half.

PLATE XIV.

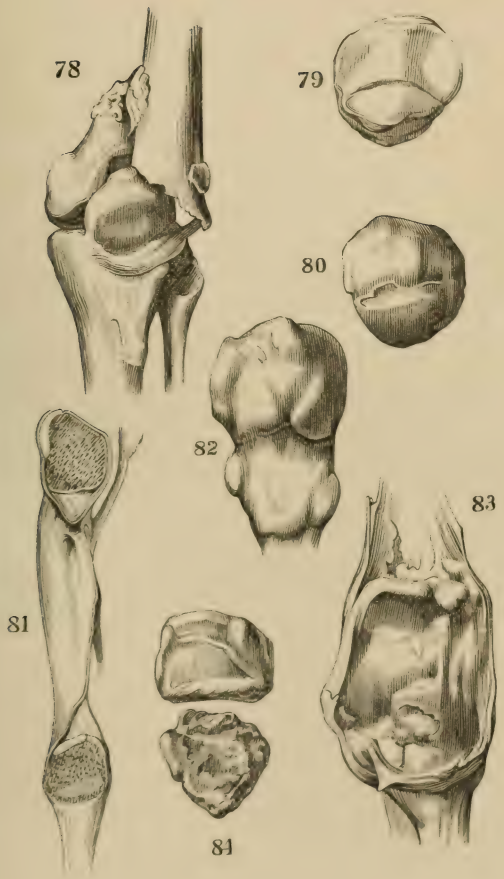

PLATE XV.

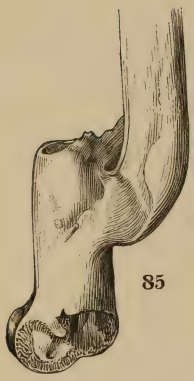

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PLATE XV.

FIG. 85.—*Fracture above the condyles of the femur, apparently transverse.* (*Musée Dupuytren*, No. 135.)—The fracture is seated 11 or 12 centimètres above the condyles. Both fragments have maintained almost entirely their vertical direction: but the lower one is drawn backward about two centimètres. The overlapping is about five centimètres, and the antero-posterior diameter of the bone is more than doubled at this point. The callus is formed by two large masses of bone, the inner of which is five centimètres in width, and descends obliquely from the upper to the lower fragment: the outer one, only three centimètres wide, has a perfectly transverse direction. Above this latter is seen the orifice of a canal drilled vertically in the callus, closed up inferiorly, and of the same calibre as the medullary canal of the femur. The effort at repair seems to have been limited to the corresponding faces of the two fragments: the medullary canal is seen to remain open in the lower fragment, and the same was the case with the upper.

This displacement, and this disposition of the callus, give the specimen considerable importance; but it derives still more from the apparently transverse direction of the line of division. The upper extremity of the lower fragment is indeed seen to be squarely cut: but on the other hand the surface thus presented is only two centimètres in width, indicating a loss of substance in the bone transversely, while the upper fragment seems cut obliquely at its anterior face. It might however be alleged that this was due to rounding off of the angle by the pressure of the soft parts: and the only way to decide the point would be by sawing the bone vertically from before backward. This section I had made quite recently; it showed the anterior wall of the shaft to have been divided at a much higher level than the other, so that the fracture at this point was oblique downward and backward.

FIG. 86.—*Fracture of the upper extremity of the tibia, oblique downward and forward.*—The inner face of the bone is shown: behind it the fibula is seen to be fractured in its upper fourth.

FIG. 87.—*Fracture of the tibia, oblique downward and backward.*—The bone is seen at its inner side.

FIG. 88.—*Fracture of the tibia, oblique downward and inward.*—Both bones are seen in front; the fibula is fractured at about the same level, proving the cause to have been direct violence.

FIGS. 89 and 90.—*Fracture of the tibia, oblique downward and inward.*—Here the fibula is broken higher up than the tibia, showing the violence to have been indirect.

PLATE XVI.

Figs. 91 and 92.—*Fracture of the lower part of the leg, by crushing.*—The patient, an old man, was thrown from a third story window, and died a few hours afterwards.

Fig. 91 shows the bones as seen in front. The inner malleolus is detached, the line of fracture being antero-posterior, as seen in *Fig.* 92. The tibia is fractured in its spongy portion, very irregularly, presenting large rough serrations, with gaps left by the loss of several small splinters. The lower fragment is itself divided vertically from right to left, down as far as its articulating surface. (*Fig.* 92.) Lastly, the fibula is broken a little higher up; its malleolus, remaining intact, preserves its relations with the tibia. There is very marked angular displacement; the upper fragment of the fibula forming the apex of an angle salient inward, and elevating the skin by its sharp point.

Fig. 93.—*Fractures of the lower extremities of the tibia and fibula, and of the posterior extremity of the calcaneum.* (*Musée des Hôpitaux.*)—The outer aspect of the specimen is shown, so as to display the fracture of the calcaneum. The posterior portion of this bone is in the first place separated by a vertical fracture running from side to side; there are also some wide but very thin splinters detached from its outer face. Its anterior portion is intact.

The fracture of the fibula is seated a little above the articulation, the malleolus remaining entire. In front, a large piece is seen separated from the tibia; another, still larger, comprises the whole inner malleolus; a third, much smaller, is formed of part of the articular surface, and is buried in the spongy portion of the bone. The articular surface therefore presents one division from before backward, and another running transversely, as in *Fig.* 92; besides an imbedding of a splinter separated from its anterior part; while its posterior portion remains perfectly sound; the crushing has affected only the front part of the bone.

Fig. 94.—*Fracture of the lower extremity of the fibula, by abduction.* (*Musée des Hôpitaux.*)—This case was published by M. Maisonneuve in the *Arch. Gén. Méd.*, 1840, tome iii, p. 171. (See text, pages 653 and 656.)

Fig. 95.—*Fracture of the lower extremity of the fibula, supposed to be by adduction.* (*Musée des Hôpitaux.*)—The entire specimen comprises both bones of the leg, with the astragalus and calcaneum; but as the fibula is the only bone affected, it is shown by itself.

The fracture commences on the outside, six centimètres from the malleolus, and shows quite marked serrations, into the most considerable of which fits the summit of the lower fragment. Thence it descends very obliquely inward, so as to terminate near the middle of the tibio-peroneal articulation, and two or three millimètres from the tibio-tarsal. The two fragments remained attached to the tibia, but it may readily be imagined how feeble the connection of the lower fragment was.

Fig. 96.—*Fracture of the lower extremity of the left fibula.* (*Musée Dupuytren*, No. 231.)—The specimen consists merely of the fibula. The fracture is of ancient date, and consolidated with very marked tilting outward of the lower fragment; it is, like the preceding, directed obliquely downward and inward, the two specimens being strikingly similar. The fracture extends upward to six and a half centimètres from the tip of the malleolus, and below to a few millimètres above the articular facette. The lower fragment has been carried outward some four millimètres, but *en masse*, without any tilting. The upper fragment seems also to have been separated from the tibia. Lastly, there springs from the front of the bone, near the upper termination of the fracture, a bony stalactite like the styloid process of the temporal, pointing transversely inward.

Fig. 97.—*Double fracture of the right fibula, probably by direct violence.* (*Musée Dupuytren*, No. 230.)—The inner face of the bone is seen. Six centimètres from the tip of the malleolus there is a nearly transverse fracture, the upper fragment of which is thrown backward. Nine centimètres higher up is another fracture, not consolidated; the upper fragment is wanting; the end of the lower is rounded off, and the medullary canal obliterated.

Figs. 98 and 100.—*Crushed fracture of the calcaneum, at the forty-eighth day.*—An insane man, aged 45, jumped from a height of seven or eight yards, alighting on both heels; both calcaneæ were broken. I applied lateral splints, which were kept on until the thirty-third day. An intercurrent affection carried off the patient on the forty-eighth day.

Fig. 98 represents the right calcaneum; it is crushed especially at the level of its larger articular facette, where its thickness is reduced to three centimètres. *Fig.* 100 shows by a horizontal section the abnormal increase in its width. The specimen, at the level of the lesser apophysis, is six and a half centimètres wide, the excess affecting chiefly the inner side. *Fig.* 100 shows the lacunæ left in the callus, even after so long a time; the interspaces between the fragments are just filled by spongy tissue, redder, softer and less dense than the bony texture; at several points the union is through the medium merely of a soft, tomentose, membrane-like substance.

Fig. 99.—*Crushed fracture of the calcaneum, at the thirteenth day.*—See text, page 670.

PLATE XVI.

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